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Molding and Casting Heavy Steel Anchor Chain

Shipyards' Need for Large Chain Cable is Met Through the Adaptability of a Malleable Foundry—How Quantity Production Was Attained

WHEN the QUISTCONCK slid from the ways last Fourth of July as Hog island's first tangible offering to the world's shipping, most landsmen visualized a masterpiece in marine engineering. The genius of the world's greatest shipyard was represented here. Something of a distinct shock, therefore, resulted when this vessel, fully equipped and ready for the sea, was not given a first-class registry. Lloyd's did not impose a second-class rating, but merely withheld the equipment number temporarily for the reason that when she sailed on her initial voyage, she carried an anchor chain with two imperfect links. This instance demonstrates the importance assigned to anchor chains by the final court of marine judgment. Further, it gives the reason for the intimate care demanded in manufacture of this major safeguard of the ship at sea. Anchor chain, since ancient times, has been a product of the forge shop. The same implements used in its manufacture, forge, hammer and anvil have descended with little improvement on the tools used by the Greeks when they equipped their fleet to sail on Troy. It was not until the past few years that it was found possible to substitute steam or air-driven hammers and presses for the smith's brawny arm. Lack of homogeneity and strength, both in the welded joint of the link and in the entire chain as a unit, were attributed to chains which were power-forged. The Boston navy yard was the first to substitute machine-welding for hand welding. Chain up to 3 inches in size, previously had been forged by hand, each link as a unit. Intermediate links were bent by hand, the edges scarfed by peening with a sledge and finally they were welded into the separate links to form the chain. When the PENNSYLVANIA was built, 3¼-inch anchor chain was specified. The undertaking was so stupendous that when two sample lengths of three links each were made each gang took an entire day at its task and remained away from work the following day to rest. This constituted an output of 1½ links per day for each gang. With the substitution of machine bending of bolts, and power

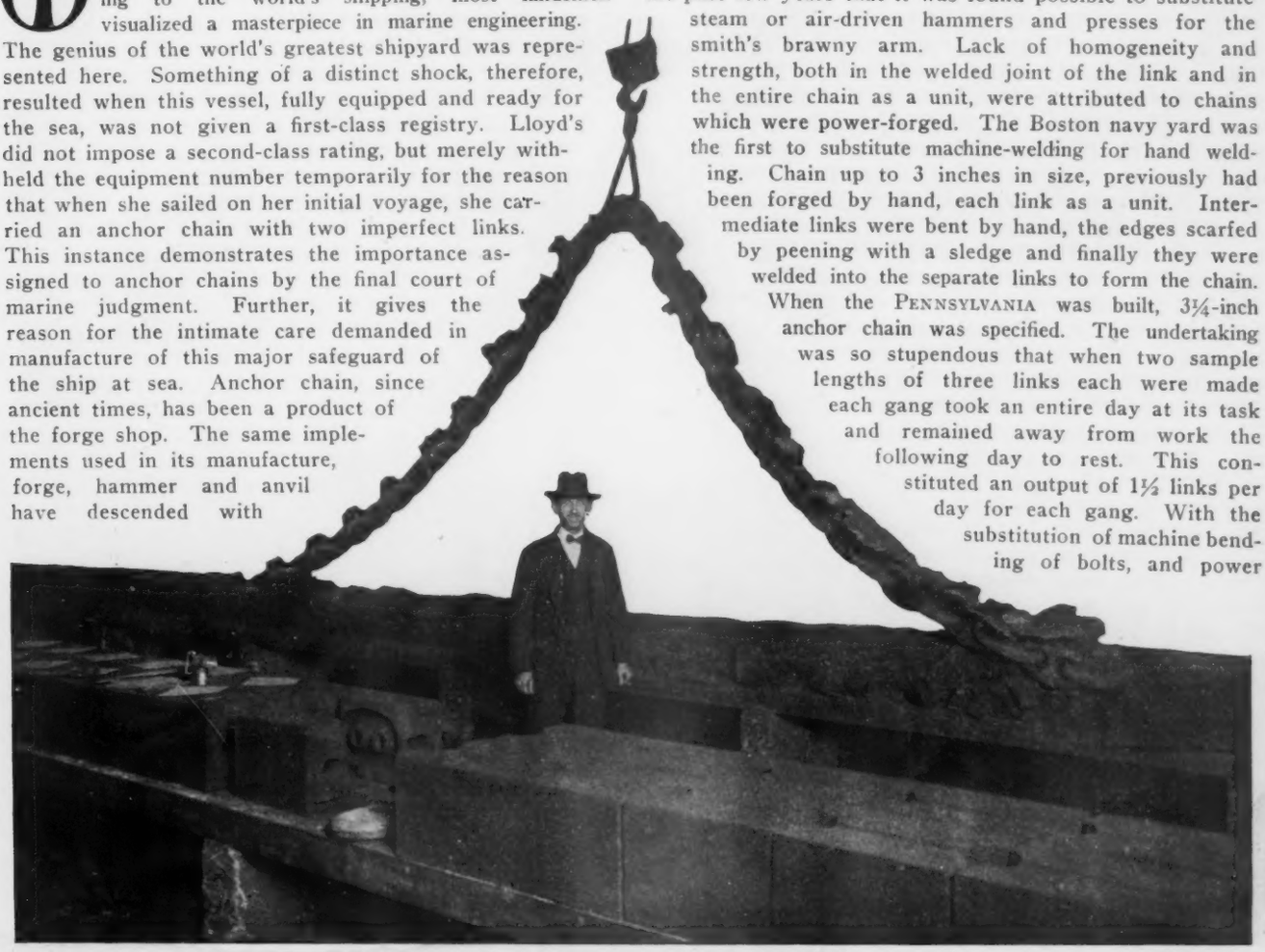


FIG. 1—EFFECTIVE SHAKE-OUT OF THE COMPLETED SHOT OF CHAIN IS POSSIBLE THROUGH THE USE OF THE MAIN AND AUXILIARY HOISTS ON AN ELECTRIC OVERHEAD TRAVELING CRANE—IN THE CENTER IS FREDERICK KNADLER, THE SUPERINTENDENT, WHO DEVISED THE MOLDING METHOD AND ARRANGED THE MOLDING LAYOUT

hammer welding and forging an output of 20 links per day was possible with each gang. During the past year the Emergency Fleet corporation has put in service about 650 ships, including contract steel and wooden vessels and those under construction which were requisitioned at the shipyards. Conservatively estimated, each ship put in service required 20 *shot* of 15 fathoms each or about 1800 feet of anchor chain. This meant that during the year just past we should have had to supply over 225 miles of anchor chain before our merchant fleet alone was outfitted. Add to this total what would have been required for vessels of war, for replacement and reserve and the total constitutes a production of anchor chain which would have taxed the entire forging capacity of the country for many years.

FIG. 2—ONE OF THE THREE MOLDING MACHINES EMPLOYED IN MAKING MOLDS FOR THE INDIVIDUAL LINKS—THE DRAW TABLE IS PIVOTED AT THE RIGHT

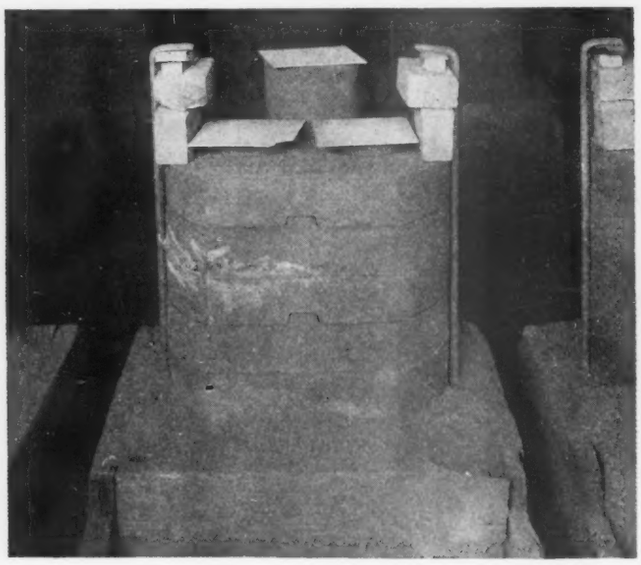


FIG. 3—SECTIONS FORMING A MOLD ASSEMBLED, IN WHICH EIGHT INDIVIDUAL LINKS ARE CAST AT ONE POURING

FIG. 4—GATE OF CASTINGS MADE IN THE MOLD, FIG. 3—NOTE THE HEAVY GATES BETWEEN THE LINKS

In this great extremity the foundry industry met the emergency. Forging yielded to molding and a new field of great possibilities was opened to manufacturer of steel castings.

It is a coincidence that the pioneer in this field should have been a company primarily engaged in the manufacture of malleable iron, although also a maker of steel castings. The National Malleable Castings Co., Cleveland, was the first to undertake and successfully make in quantity cast steel chain of sufficient strength for anchor cable.

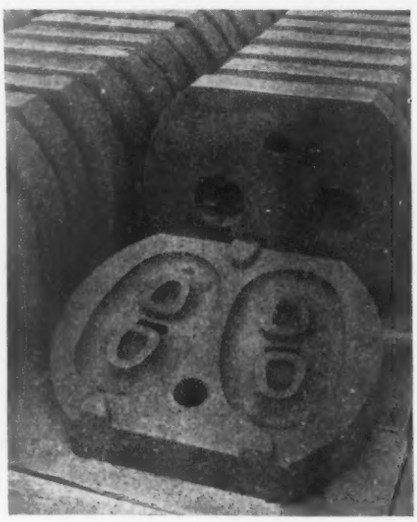


FIG. 5—ONE OF THE SECTIONS FOR THE INDIVIDUAL LINKS, SHOWING THE POURING RUNNER OPENING AND RESTRICTED GATE

It was recognized from the start that the chain molding essentially involved two distinct steps. First the individual links had to be made and finished, and then intermediate links had to be cast around them. Anchor chain is made in units known as *shots* which are 15 fathoms or 90 feet long. The *stud* or bar link is commonly used as it does not kink or foul as easily as the common open link. The separate links presented little difficulty as a molding problem. A sectional dry sand mold is used, each section formed by two half molds accommodating two links. Four of these sections placed vertically allow eight separate links to be poured together.

A machine similar to that shown in Fig. 2 is used for the individual molds. All machines used on this work were built by the Cleveland Osborn Mfg. Co., Cleveland. With the mold box or flask erect, a small amount of new sand is packed around the bosses shown at *A*, and used sand then is added until the mold is about half full. Wires are bedded-in forming a single loop around the circumference of each link mold. These wires support the mold against the lateral thrust of the metal when the mold is poured. The flask then is filled with sand. The mold is jolted from 16 to 20 times, the sand leveled to the sides of the mold box, and a ribbed metal bottom plate, thoroughly vented, is

placed and secured by the self-adjusting clamps shown at *B*, Fig. 2. The table of the machine then is raised, rolled over and the draw table which pivots laterally on one of the columns is swung around underneath the inverted mold. The table then is lowered vertically until the bottom plate rests on the draw table, and the clamps are released so that the plate and mold have an even bearing. The pattern is then drawn, the completed mold swung from under the jolt table which again is turned over into jolting position. The completed mold section is placed upon a rack holding 24 sections. When the entire rack is filled, it is lifted by a storage battery truck and conveyed to the drying ovens.

Fig. 5 shows the bottom or drag half of one of the sections. It may be noted that lugs which engage recesses in the cope section at three points, provide a register, so that the two halves of the section fit accurately together and are secured against lateral slippage. The cope half section is shown on the machine in Fig. 2. The sections have a main pouring gate as shown in the front of the mold, Fig. 5, and slotted bottom-pour gates in the center of the stud portion of each link. These gates are fed with molten metal through horn gates at the bottom of the assembled mold. As the metal rises it is fed simultaneously to each of the two links in each section. The manner of assembling the sections is shown in Fig. 3. Here it may be noted that the mold for the two bottom rows of links are set in a flask and firmly bedded and reinforced against outward metal pressure by sand which is rammed into the flask. The entire mold is held closely together and the lifting force of the molten metal is resisted through staple clamps wedged in place as shown. The pouring runner is raised above the top of the upper section to provide an additional head for the metal in the two top links.

The method of gating is clearly in-

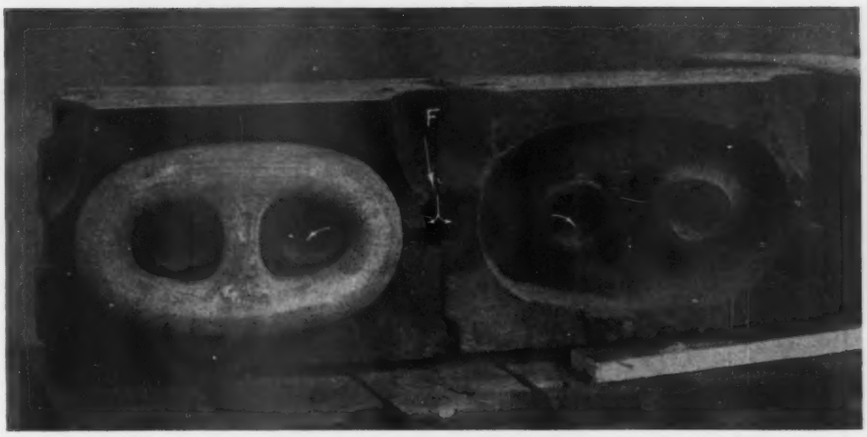


FIG. 8—CLOSE-UP OF CONNECTING LINK MOLD SHOWING THE PRE-CAST LINK IN POSITION AND THE PATH FOLLOWED BY THE MOLTEN METAL IN FORMING THE INTERMEDIATE LINKS

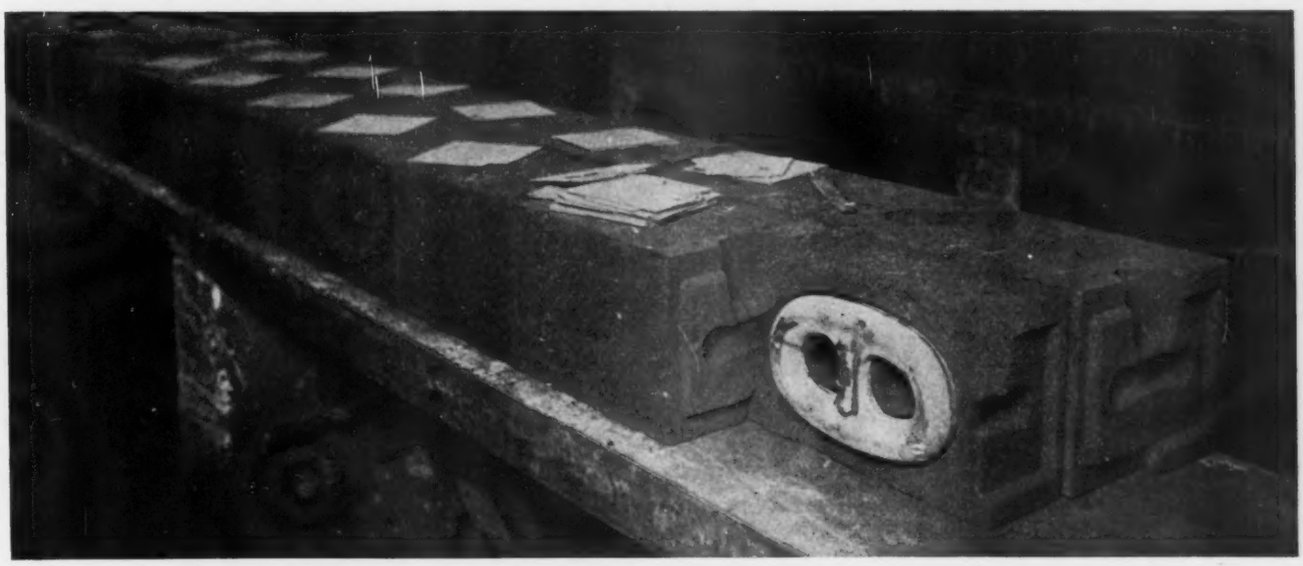


FIG. 6—METHOD OF ASSEMBLING THE INDIVIDUAL LINKS IN THE MOLDS PREPARATORY TO POURING THE CONNECTING LINKS

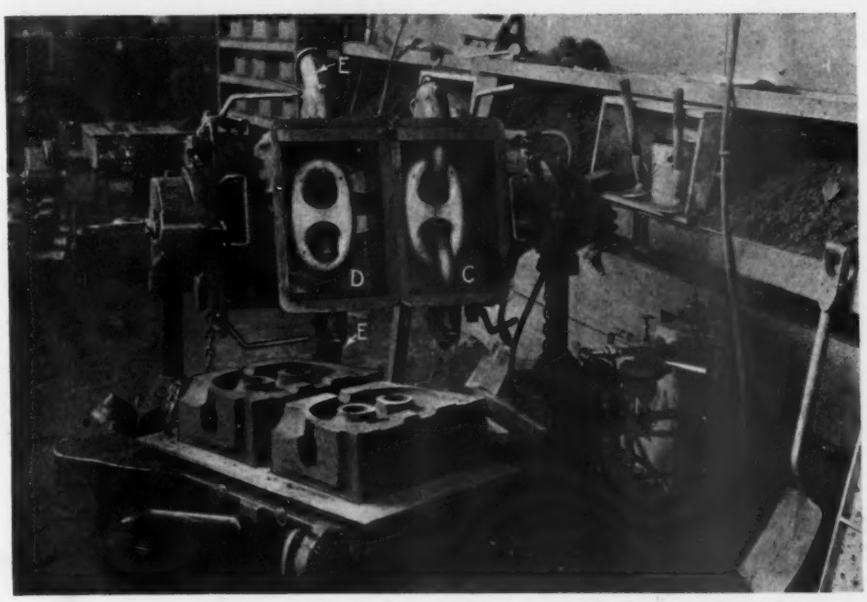


FIG. 7—MACHINE EMPLOYED IN MAKING THE MOLDS FOR THE INTERMEDIATE LINKS—THE QUARTER CONNECTING LINKS ARE IN SECTIONS AND MAY BE WITHDRAWN AS SHOWN IN BOX *C*

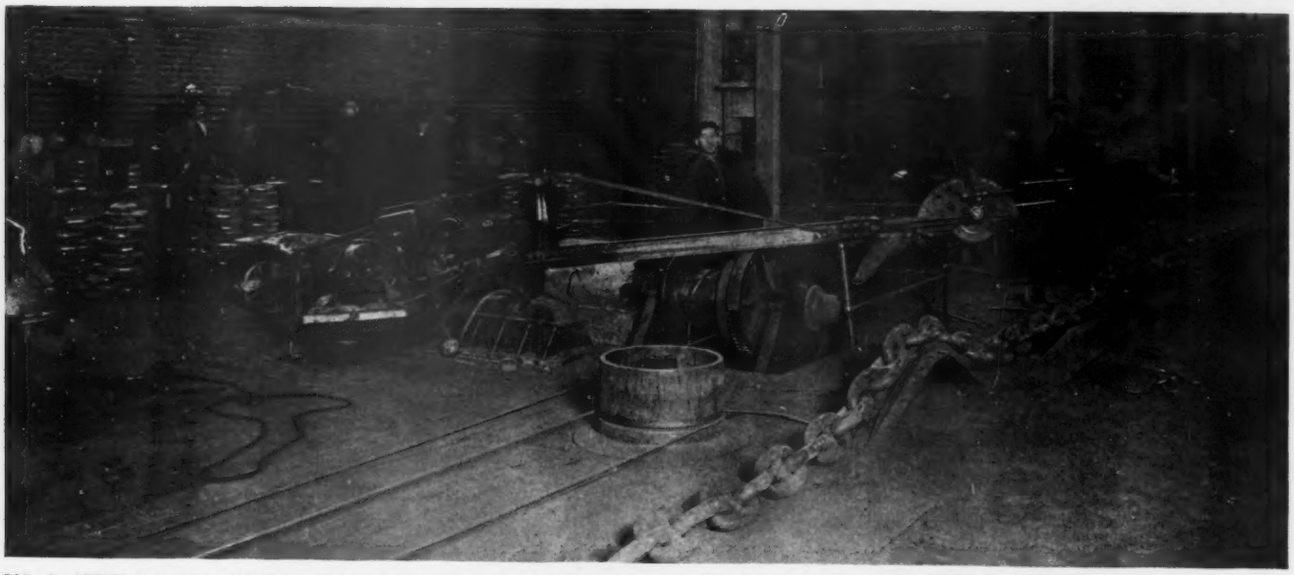


FIG. 9—SECTION OF THE CLEANING ROOM WHERE THE CHAIN LINKS ARE GROUND AND FINISHED—NOTE THE RIG FOR HANDLING THE LINKS IN THE COMPLETED SHOT

dicated in the eight-link gate of casting shown in Fig. 4. The metal flows through a runner to the bottom of the multiple mold where it divides and passes through the two horn gates, and rises through the successive sections. Each link is gated at the stud. The gate for each successive link becomes the riser for the one preceding. It will be noted that the section of the gate is contracted at the plane where it joins the stud, in each instance. This prevents the gate with its greater cooling area from drawing metal from the link immediately above it; or from breaking away from the stud, which being of lighter section cools more rapidly than the gate. The reduction of area at the junction between the link and gate also facilitates breaking the gates off when the casting is cooled.

In addition to the gates which serve as risers for the links on the next lower mold section, two small risers are placed at the opposite ends of each link circumference.

After the gates and risers are removed the links are tumbled and delivered to the grinding floor. To facilitate grinding, semicircular wooden racks have been constructed. These are set at a convenient height from the ground and contain 20 compartments in which the individual links are laid flat with one side exposed for grinding. Slots are provided in the same frames so that the links may be held with the edges exposed. Swing grinders are used. After grinding, the individual links are ready for assembly in the molds where the intermediate links are made.

The molds for the intermediate links do not possess the simplicity of those just described. It is necessary to provide a recess in which the individual links may be held, separated at all points from the new metal which will

FIG. 10 — SECTION MOLD USED TO BUILD-UP BETWEEN SOUND LINKS IN REPLACING A DEFECTIVE LINK WHICH HAS BEEN CUT AWAY BY THE TORCH

form the circumference, stud, and riser for the intermediate link. The pattern assembled and the machine upon which these molds are made two at a time, are shown in Fig. 7. The link pattern which is flat in the bottom of the box, forms the recess into which the individual link fits. Looped into this portion of the pattern at each end is a quarter of a link. The flask likewise carries a quarter of a stud and of a runner or gate. The quarter link segments are divided. One portion, doweled at the end is firmly attached to the pattern plate. The other, with a recess at its end for the dowel mentioned, continues through the end walls of the mold box and through a sleeve of the same radius, rigidly fastened to the outer wall of the box. A loose piece, practically a false end to the mold box, is necessary to form the panel at the end of the mold where the sections are subsequently joined end to end. Recesses in the face of the section are formed by the projections at the side of the complete link pattern in the bottom of the mold box. These recesses are engaged by lugs in the opposite molds

FIG. 11—AN IMPERFECT LINK HAS BEEN CUT OUT WITH THE OXYACETYLENE TORCH AND A NEW LINK HAS BEEN CAST IN PLACE BY THE USE OF THE MOLD SECTIONS INDICATED IN FIG. 10

which are made on another machine and secure the two facing sections against end thrust when they are assembled, as will be explained later.

In molding the sections for the intermediate links, with a few exceptions, the same general procedure is followed as in the case of the separate links. The two-link sections are molded at the same time, but they are contained in separate flasks on the table of the molding machine. The pattern is arranged as shown in the box *C*, Fig. 7. A light surface of new sand, followed by the entire required quantity of remixed sand is placed in the flasks at the start. After jolting from 15 to 20 times, the sand is leveled and the bottom plate is fastened in the manner previously described. The jolt table with the mold then is raised and rolled-over. Next the portions of the connecting link patterns shown at *E* in the box *D*, Fig. 7 are pulled from the mold into the sleeve outside the box. In this manner the end of the box acts as a stripping plate for the link segements which are withdrawn. The jolt table then is lowered until the mold plate rests on the swinging draw table which previously has been placed in the proper position for receiving the completed mold.

The clamps holding the bottom plate and mold in position then are released and the pattern is drawn. The loose piece which has been referred to as a false end to the mold, is slipped laterally from the end of the mold and is replaced in the flask after the machine table is again rolled over to its initial position ready for making another mold.

The following mixture is used for the dry molds:

Silica sand, 20 shovelsful.
Old core sand, ground and mixed, 10 shovelsful.
Pitch, two shovelsful.
Liquid core binder, 1½ gallons.

The molds for the connecting or intermediate links are baked on racks in a manner identical with that followed with the individual molds. They then are ready for assembly as shown in Fig. 6. The layout for handling the connecting link molds is novel and effective. To enable the men to work with greater comfort, and to provide a solid and level surface upon which to assemble the molds, a number of reinforced concrete tables were constructed. These are 2 feet high, 30 inches wide and long enough to hold an entire shot or 90 feet of chain. These tables are of a convenient height to enable the workmen to walk beside them and assemble the molds without physical discomfort.

Fig. 8 indicates the manner in which two successive sections of a mold fit together end to end. The completed single link is held in position and separated from the portion in which the metal for the connecting links will be poured, by the two bosses which carry the mold for the link circumferences. The pouring gate is shown at *F* and the arrows indicate the path of the molten metal which forms the connecting link. It will be noted that the gate leads to the stud and that it is restricted where it joins the casting so that it may be knocked off easily. An entire table of molds assembled is illustrated in Fig. 6. The molds for two entire shots are placed side by side on the table. These two lines of molds are held together by cross clamps wedged in place. Great care is exercised in joining the successive sections end to end, and also in placing the opposite sides together face to face with the completed link within. The joining surfaces are filed and fitted so that no chance opening is allowed for a run-out. Four small risers are provided which surround the gate on each connecting link. These may be noted in Fig. 1, on the chain which has just been lifted from the table.

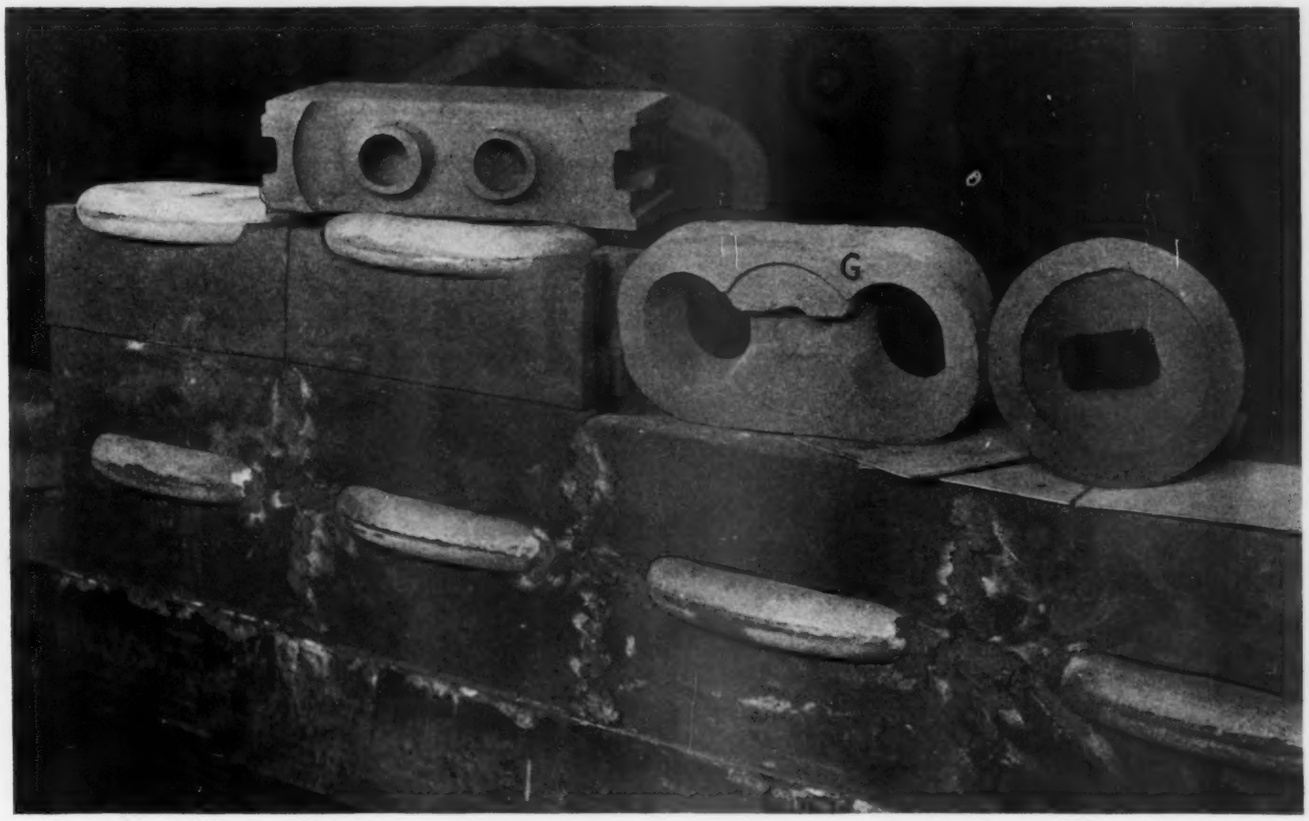


FIG. 12—IMPROVED METHOD OF MOLDING TWO COMPLETE SHOT OF CHAIN, ONE SUPERIMPOSED UPON THE OTHER, AND IN SOME CASES FOUR SHOT TOGETHER WITH TWO ROWS SUPERIMPOSED AND SIDE BY SIDE

A new system recently has been adopted for increasing the speed with which the intermediate links may be molded and cast. Fig. 12 illustrates the arrangement of the mold sections for this work. Two shots of chain are superimposed, the individual links being placed in the mold horizontally instead of vertically and the intermediate links are gated at the circumference or edge of the link instead of through the stud. The two superimposed rows of molds

are placed parallel with the one set in the manner shown, and the gate *G* is placed across so that it fills the top links in the two top rows of molds simultaneously. The runner *H* is set in place in the center of the gate to receive the metal. In each row of molds the metal flows into the top link mold and down to the link on the bottom.

Fig. 1 illustrates the method of shaking-out. The main hoist of the overhead crane is hooked at one-fourth the distance from one end of the shot and lifts the chain as shown. The crane then is propelled forward until it is over a point about one-fourth of the distance from the opposite end. The auxiliary hook engages the chain at this point. The entire shot is lifted free in four lengths hanging from two hooks, and deposited on the floor at another part of the foundry where the gates and risers are knocked off. The shot then is tumbled in one of two tumbling barrels installed by the W. W. Sly Mfg. Co., Cleveland. Tumbling chain is effective as the links, in working around and striking one another clean themselves. After tumbling, the shot is ready for grinding.

A special rig was devised for grinding the completed chain, in order to conserve floor space. This layout is shown in Fig. 9. The chain pulled by a steel cable is dragged over the two elevated portions of a guide track, composed of separate steel plates with longitudinal side ribs. Each of these elevated sections is commanded by a swing grinder. As each successive intermediate link comes into position on this improvised table, the studs and flat surfaces are ground. A bar then is inserted in the link, and it is turned by a workman who holds it in position for grinding the edges. The cable pulling the chain is drawn around a drum, then back to the second drum shown in the foreground of Fig. 9, around a third drum, and back to an electrically-driven winch. In this manner the chain at no time stretches more than one-fourth its length in advance of the first grinder. By using two grinders the work is greatly expedited.

If defective links are found at this stage or are developed later by the physical tests, they are cut out with an oxyacetylene torch and new ones are cast in place. The mold shown in Fig. 10 is used for casting these repair links. This mold facilitates the joining of the complete links and makes it possible to build the mold at any point along the length of chain. A repaired link at the end of a shot is shown in Fig. 11.

After grinding, each shot of chain is heat-treated. Preparatory to this operation, the chain is formed into loops about 15 feet long, by engaging each of four hooks at equal distances along the shot. These hooks are secured to short bars by a clevis and pin connection. The four bars in turn are fastened to a cross beam mounted upon rollers, which support the rig and allow it to be pulled across the steel furnace and approach floors with a minimum of drag friction. This rig for dragging the chain is connected through cables to a winch which is used to haul the shot into the heat-treating furnace, and later into the quenching tank. A second winch hauls the shot into the drawing furnace and out upon the cooling floor as is shown in Fig. 13.

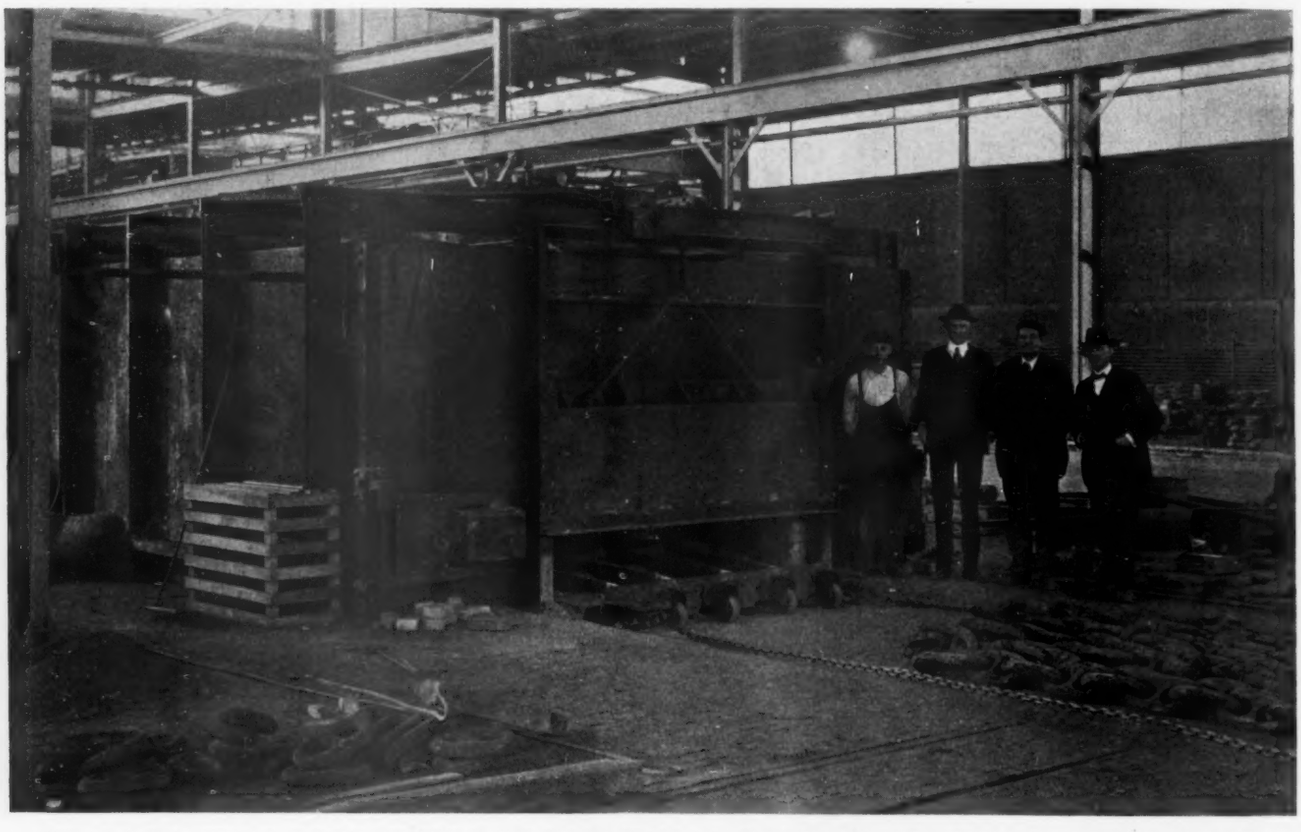


FIG. 13—ONE OF THE TWO ELECTRIC FURNACES WHICH HEAT-TREAT THE COMPLETE SHOT OF CHAIN BEFORE IT IS TESTED—THE FURNACE ILLUSTRATED IS USED IN THE DRAWING OPERATION

Pyrometer-controlled electrical heat is used in the heat treating and drawing furnaces. Both furnaces were built by the Electric Furnace Co., Alliance, O. In the first furnace, the temperature is raised slowly to about 900 degrees Cent. and is held at this point for about 10 minutes. The shot then is dragged from the furnace and into a 10 x 40-foot quenching tank, where a circulation of cold water is maintained. From this tank the shot is dragged by the second winch into the drawing furnace and again heated. Here a temperature of about 550 degrees Cent. is attained, after which the chain is dragged out onto the floor and allowed to cool in the air. The drawing furnace is shown in Fig.

13. Following the heat treatment, the chain is tumbled to remove all scale before it is taken to the testing floor.

Representative of Lloyd's and the American bureau of shipping give the chain a dual inspection and test. Both static and dynamic tests are applied. A Reihle type hydraulic testing machine is used to test the entire shot as a unit. This machine was constructed by the National Malleable Castings Co. from drawings furnished by the manufacturers of this type machine. It was built and installed in 60 days. The compression members are carried in concrete, with the trench in which the chain is placed, between them. This arrangement provides a safeguard against the sections of the chain swinging horizontally should a break occur. This machine has a capacity of 700,000 pounds.

When the complete shot is cast, 123 links are formed. Following the grinding operation, the inspectors select three links for the jerk test. The two links at each side of this triplet are cut out by oxyacetylene torch, and a new link connecting the two broken portions of the shot is cast in place. This leaves 119 links, the total required in the 90-foot length of the shot. The triplet, together with connecting clevis and pins for attaching the shot to the frame and draw-head of the testing machine are wired to the shot and receive the same heat treatment, quenching and drawing which is applied to the shot. When the completed chain reaches the testing floor the triplet is removed for the jerk and maximum load tests.

The triplet is subjected to a jerk test of three blows on a drop test machine. This machine is similar to that used by the Master Car Builders' association with the exception that a 3000-pound tup and heavier anvil is used in the chain test. The car builder's machine uses a 1640-pound tup. In the jerk test the triplet is subjected to three blows from the tup dropped successively from 8, 9 and 10 feet. The same three links then are subjected to a static test consisting of a 400,000-pound vertical pull. The entire shot from which the triplet was cut, then is placed in the large horizontal machine and subjected to a 285,000-pound proof load. Following this test the shot is placed alongside of a trench which is deep enough to allow the inspectors to turn over and examine each link without the inconvenience of bending to the floor. Indications of concealed blowholes near the surface are tested for thoroughly by tapping the links with a sharp pointed hammer. Defects in any link result in the chain being returned to the foundry floor to have a new link cast in place.

The severity of these tests may be realized from the fact that each link of anchor chain is only 2½ inches in diameter, weighs about 32 pounds and the entire shot weighs approximately 4300 pounds. The output of this foundry has been in excess of 13 shot or about 1500 feet of anchor chain per day. It was the intention, had the war continued, to make over 100 tons per day. This would have represented a mile of anchor chain every 24 hours, and would have gone far toward supplying a great portion of the 225 miles or more which would have been needed for this year's ships. This performance is doubly remarkable in view of the fact that the foundry was built and equipped primarily to make malleable castings by a process which involves triple refining. The plant and its equipment to do this work will be described in the forthcoming, April 15, issue of THE FOUNDRY.

Elementary Points on Steel Converter Practice

By George P Fisher

MAKING steel castings by the converter process involves the use of the raw materials of the foundry, namely pig iron, scrap, etc., and changing them into steel. To convert pig iron into steel, certain impurities have to be removed. The process is acid, that is, one in which the furnace is lined with refractory material having silica as its base. It is possible to remove by oxidation, carbon and manganese, but neither sulphur nor phosphorus are reduced. These need a basic lining which is unsuited for converter use. It, therefore, is necessary to use melting stock low in phosphorus and sulphur. In steel castings, 0.08 per cent sulphur and 0.06 per cent phosphorus usually are the permissible limits in the finished product. As there is a tendency for these elements to increase owing to the charge shrinking in weight while the same amount of sulphur and phosphorus remain therein, we should specify the contents of these two elements at about one-half of the foregoing limits in buying iron.

With reference to the elements other than phosphorus and sulphur, it is well to keep in mind that after the iron has been melted in the cupola and transferred to the converter, no more external heat is applied and to maintain and increase the temperature of the metal, we must depend upon heat generated by the combustion of silicon and carbon. Iron contains approximately a uniform amount of carbon, namely about 3.5 per cent. The silicon varies, and it is generally on this content that pig iron is graded and bought. The iron which contains the largest amount of silicon in proportion to its price, all other things being equal, is the cheapest to buy, as it contains the most of the principal heat-giving element and also makes it possible to carry a higher percentage of steel scrap in the cupola.

Manganese should be specified as high as possible, because its function is to hold down the sulphur content of the mixture. If there were no sulphur present in the mixture, it scarcely would be necessary to have much manganese.

The converter lining is important. Two materials may be used, namely silica brick or ganister. Either is good, but ganister is cheaper and it lends itself more readily to economical repairing. Preheating the converter is one of the most important operations in the whole process. If the converter is not preheated properly, it makes difficult blowing, results in cold metal and excessive slopping during the boiling period.

After the converter is hot and the iron charged, an important factor is the correct setting of the vessel. The converter should be tilted so that the metal seems about to enter the tuyeres.

The three periods of the blow follow: When the flame makes its appearance and the bulk of the silicon is eliminated, is the initial period. The second stage is known as the boil or manganese period. During this time the manganese is oxidized, going into the slag, making it thin and accounting for its greater tendency to slop over and to permit of the formation of a long flame. The last, or carbon period, comprises all the time from the end of the boil to the end of the blow. The carbon first passes off gradually, but when it is reduced below 1 per cent, the action speeds-up greatly until carbon appears to be eliminated almost entirely. The brown smoke at the end is an indication that the oxygen is attacking the iron itself, after eliminating the other elements.

From a paper presented at a recent meeting of the Pittsburgh Foundrymen's association. The author is with the Whiting Foundry Equipment Co., Harvey, Illinois.

Ferruginous and Other Bonds in Molding Sands

Naturally Bonded Sands and Those of High Silica Content Both Are Used in European Practice—Detailed Analyses of English Sands Are Given

By P G H Boswell

MODERN foundry practice, so far as the use of molding sands in the casting of steel is concerned, falls into one or other of two classes. In the countries of western Europe, particularly Great Britain, France, Belgium and Germany, the practice has been to use naturally bonded molding sands, that is, sands such as French Red, consisting of comparatively coarse material bound together with clay substance and ferric hydroxide. To a much smaller extent (but, the writer is informed, widely in the United States) it is the practice to use highly siliceous sands bonded artificially with such substances as sugar, dextrin, molasses, oil, *sulphite-lees* (a by-product from the manufacture of paper) and others. Sometimes fireclay, with or without one of the artificial bodies just mentioned, is added for the same purpose. The strength of naturally bonded sands is occasionally increased by the use of similar artificial substances. Particularly is this the case when the binding material, as in the Scottish *rotten rocks* or *rotten stones* is insufficient by itself to yield the structural strength required. The bond of the rotten rocks used so largely in the Clyde valley and the district around Glasgow, consists of micaceous and kaolin-like material, which, however, is not so plastic as is desirable.

British Molding Sands

The naturally bonded molding sands used in Britain may be divided into two chief classes: Those used in casting iron, as well as brass, bronze and other nonferrous alloys; and those used for steel.

Of the former, some of the best known are the Red Bunter sands from Mansfield and Birmingham, the Erith loam, Thames sand, etc. Among the latter are the famous Belgian Red, Belgian Yellow, French Red, French Yellow, Cornish Red, South Cave (Yorks) Huttons Ambo (Yorks), Barrow-in-Furness (Lancs.), sand from South Africa and other more distant localities.

Table I

Percentage of Weights

	Coarse sand grade 0.5 to 1mm	Medium sand grade 0.25 to 0.5	Fine sand grade 0.25 to 0.1	Coarse silt grade 0.05 to 0.1	Fine silt grade 0.0 to 0.05	Clay grade under 0.01 mm	Total sand grade, under 0.1 mm per cent
Belgian Yellow	7.5	64.9	12.0	3.3		12.3	84.4
French Red	0.6	18.0	62.7	3.1		15.6	81.3
Cornish Red	0.6	37.3	42.7	5.7		13.7	80.6
Barrow-in-Furness	5.5	39.6	32.6	0.2	6.2	15.9	77.7
Huttons Ambo, Yorks	0.4	16.1	72.0	0.2	0.3	11.0	88.5
Auchenheath N. B.	27.5	41.1	26.2	0.2	1.0	4.0	94.8
South Africa	0.5	3.4	70.5	1.0	6.3	18.3	74.4
A "core-sand" mixture	9.0	10.4	0.3	0.2	4.8	17.7	77.2
A good "greensand" mixture	4.2	15.3	61.9	57.8	2.5	15.9	81.4

The bond of all molding sands may be regarded from two distinct points of view. Bonding may result from a mixture of certain chemical compounds, the composition of which has been obtained in the course of chemical analysis, or it may be the result of inherent texture—the finest-grained material present in the sand, the relative quantity being estimated by mechanical analysis. The clay grade was estimated by H. Ries by settlement, but this method is not sufficiently accurate.

Considering first the mechanical analyses, Table I indicates the grade composition of some of the best steel molding sands.

Several interesting points are brought out by this table. The sand grade in each case is seen to be relatively high in amount, the clay grade, which acts as bond is also present in quantity, but the intermediate silt grades are relatively small in proportion. From the point of view of the use of the sand in the foundry, this means that there must be an abundance of coarse open sand to keep the mold well vented and to allow free passage of gases, the clay grade or bond must be sufficient; but intermediate fine material such as silt, which would pack the pores of the mold and prevent good ventilation should be absent or present only in small quantity.

Interpreting Analyses

From the chemical analyses of the sands, particularly by interpreting the analyses *rationally* we may also obtain interesting information regarding the bond. From the bulk chemical analyses given in the accompanying Tables II, III, IV, and V perhaps the one outstanding feature is the relatively high percentage of ferric oxide (estimated as Fe_2O_3). If instead of making bulk analyses, we submit the material of various

Table II

Bulk Chemical Analyses of Molding Sand

	Per cent (1)	(2)	(3)	(4)	(5)
Silica (SiO_2)	86.47	89.88	77.29	77.61	86.11
Alumina (Al_2O_3)	4.96	3.29	2.46	8.60	5.29
Ferric Oxide (Fe_2O_3)	2.58	2.23	14.16	4.81	2.45
Ferrous oxide (FeO)	0.29	0.25	0.13	1.40	0.29
Magnesia (MgO)	0.37	0.24	0.31	0.22	0.47
Lime (CaO)	0.26	0.24	0.81	0.16	0.40
Soda (Na_2O)	0.12	0.64	0.23	0.04	none
Potash (K_2O)	0.47	trace	0.52	0.46	0.95
Water above 110° C. (H_2O+)	2.44	1.76	2.58	4.05	2.26
Water below 110° C. (H_2O-)	1.54	0.74	0.95	0.92	1.31
Carbon dioxide (CO_2)	none	none	0.31	trace	none
Titanium dioxide (TiO_2)	0.40	0.36	0.15	1.41	0.34
Zirconia (ZrO_2)	none	trace	0.36	0.06	trace
Phosphorus pentoxide (P_2O_5)	0.09	0.11	trace	0.13	0.08
Sulphur trioxide (SO_3)	none	none	none	0.04	0.20
Chlorine (Cl)	trace	trace	none	trace	none
Manganic oxide (MnO)	trace	trace	0.06	0.04	trace
Barium oxide (BaO)	trace	none	none	none	none
Total	99.99	99.74	100.32	99.95	100.15

(1) Belgian yellow, (2) French red, (3) South Cave red (Yorks), (4) South African sand, (5) Cornish red.

From a paper prepared for the American Foundrymen's association. The author, Prof. P. G. H. Boswell of the University of Liverpool, was connected with the British ministry of munitions.

grades, as obtained by elutriation, to chemical analysis, several interesting points are brought out. In the accompanying tables chemical analyses of the material from various grades separated from well known molding sands are given.

With these may be compared similar analyses of the grade material of a well known Bunter iron molding sand from Wolverhampton shown in Table VI.

The first fact of importance which these tables indicate is that the sand grade in each case consists of a high-silica sand. The following are the respective figures:

Medium and Coarse Sand Grade

Medium and Coarse Sand, Under 0.25 mm. Diameter	Per Cent	
	Belgian	South Africa
SiO_2	98.63	96.53
Al_2O_3	0.19	1.06
Fe_2O_3	0.22	1.00
MgO	0.12	none
CaO	0.36	0.17
Na_2O	none	0.09
K_2O	0.08	0.28
TiO_2	none	0.34
Loss on ignition	0.25	0.56
Totals	99.85	100.03

Fine Sand Grade

Fine Sand, 0.25 to 0.1 mm. Diameter	Per Cent		
	Belgian	Cornish Red	South Africa
SiO_2	96.73	96.73	95.07
Al_2O_3	1.09	1.04	1.04
Fe_2O_3	0.69	0.50	1.83
MgO	0.15	0.13	0.13
CaO	0.17	0.26	0.17
Na_2O	0.11	0.08	0.03
K_2O	0.29	0.38	0.20
TiO_2	0.11	0.14	1.34
Loss on ignition	0.88	0.63	0.44
Totals	100.22	99.89	100.25

The percentages of alkalies (potash and soda) and alkaline earths (lime and magnesia) are seen to be low and thus the sand is highly refractory. The alumina percentage is not high, and the small quantity of ferric oxide present is mostly distributed as thin pellicles round the quartz grains which constitute the bulk of the sand.

The silt grades being unessential and present in small amount, it will be better to consider next the clay grade. A comparison of the chemical analyses is as follows:

	Per Cent					
	Belgian		Cornish		South Africa	
SiO_2	45.60		46.67		42.75	
Al_2O_3	22.19		20.78		25.88	
Fe_2O_3	10.74	11.87	12.89	13.30	12.86	13.53
FeO	1.13		0.41		0.67	
MgO	1.26		1.52		0.52	
CaO	1.84		2.27		1.35	
Na_2O	0.38		0.40		0.10	
K_2O	1.56		2.29		0.73	
TiO_2	1.24		0.85		1.05	
Loss on ignition	14.24		12.29		14.02	
Totals	100.18		100.37		99.93	

With these analyses may be compared those of two well known British fireclays of high quality:

	Per Cent	
	Church Gresley	Glenboig (A.1)
SiO_2	46.45	46.53
Al_2O_3	35.82	36.57
Fe_2O_3	1.31	1.80
MgO	0.09	0.21
CaO	0.47	0.22
Na_2O	0.76	0.37
K_2O	1.08	
TiO_2	3.65	1.47
Loss on ignition	12.14	13.16
Total	100.71	100.33

Obviously, the clay grade of the molding sands separated constitutes a high grade, refractory fireclay. There is, however, one marked difference. In each case the ferric oxide is high.

The reason for the tendency in the steel industry to use high-silica sands bonded with fireclay is explained. The method, however, does not result in the addition of ferric oxide to the sand, although an old formula for molding sands was as follows:

	Parts
Fine quartzose sand	93
Red English ochre	2
Aluminous earth, as little calcareous as possible	5
	100

The difficulty obviously lies in the effective mixing of fireclay and sand,

Chemical Analyses of Various Grades of Molding Sands

Table III

Belgian Yellow

	Per cent				
	Coarse and medium	Fine	Coarse	Fine	Coarse
SiO_2	98.63	96.73	75.57	56.69	45.60
Al_2O_3	0.19	1.09	9.82	17.96	22.19
Fe_2O_3	0.22	0.69	5.37	9.85	10.74
FeO			0.40	0.43	1.13
MgO	0.12	0.15	0.06	0.99	1.26
CaO	0.36	0.17	0.72	1.09	1.84
Na_2O	none	0.11	0.20	0.32	0.38
K_2O	0.08	0.29	0.99	1.35	1.56
TiO_2	none	0.11	0.95	1.42	1.24
Loss on ignition	0.25	0.88	5.80	10.37	14.24
Totals	99.85	100.22	100.48	100.47	100.18

Table IV

Cornish Red

	Per cent			
	Fine 0.1 to 0.25 mm.	Coarse 0.05 to 0.1	Fine 0.01 to 0.05	Coarse under 0.01
SiO_2	96.73*	92.07	55.34	46.67
Al_2O_3	1.04	3.02	18.87	20.78
Fe_2O_3	0.50	1.25	9.85	12.89
FeO		0.20	0.47	0.41
MgO	0.13	0.17	1.27	1.52
CaO	0.26	0.38	0.95	2.27
Na_2O	0.08	0.09	0.18	0.40
K_2O	0.38	0.89	2.02	2.29
TiO_2	0.14	0.42	0.85	0.85
Loss on ignition	0.63	1.21	10.14	12.29
Totals	99.89	99.70	99.94	100.37

*Duplicate determination of silica 96.65 per cent.

Table V

South African Sand

	Per cent				
	Medium 0.25 to 0.5 mm.	Fine 0.1 to 0.25	Coarse 0.5 to 0.1	Fine 0.1 to 0.05	Coarse under 0.01 mm.
SiO_2	96.53	95.07	47.60	44.02	42.75
Al_2O_3	1.06	1.04	23.96	22.58	25.88
Fe_2O_3	1.00	1.83	12.91	13.47	12.86
FeO			0.50	0.52	0.67
MgO	none	0.13	0.30	0.46	0.52
CaO	0.17	0.17	0.67	1.02	1.35
Na_2O	0.09	0.03	0.15	0.29	0.10
K_2O	0.28	0.20	0.72	0.74	0.73
TiO_2	0.34	1.34	1.12	1.00	1.05
Loss on ignition	0.56	0.44	12.32	13.22	14.02
Totals	100.03	100.25	100.25	100.32	99.93

Table VI

Bunter Sands

	Per cent				
	Medium 0.25 to 0.5 mm.	Fine 0.1 to 0.25	Coarse 0.5 to 0.1	Fine 0.1 to 0.05	Coarse under 0.1
SiO_2	94.37	89.10	85.31	69.05	58.17
Al_2O_3	2.82	5.32	6.95	14.15	19.58
Fe_2O_3	0.46	0.88	1.23	2.70	5.47
FeO			0.22	0.53	0.55
MgO	0.17	0.28	0.37	1.05	1.78
CaO	0.16	0.24	0.41	1.27	1.34
Na_2O	0.12	0.15	0.49	0.56	0.38
K_2O	1.57	3.13	3.31	5.45	5.37
TiO_2	0.06	0.21	0.43	0.97	0.73
Loss on ignition	0.48	0.71	1.43	4.28	6.34
Totals	100.21	100.02	100.15	100.01	99.71

with or without ochre. Natural agencies succeed in coating each quartz-grain more or less completely with clayey and ferruginous material. Fireclay containing fine siliceous substance should not be used, since it introduces silt grade material which fills the pores of the mold and tends to cause blowholes, scabs, etc.

It is noteworthy that castings made from the western European, naturally-bonded, ferruginous molding sands usually possess a smooth, steel-blue surface. The color appears to be due to the formation of magnetite from the ferrichydroxide in the sand. In the case of castings made from the Scottish *rotten rocks* containing little or no iron, the skin is grayer in tint and is frequently less smooth. The use of French Red sand for facing molds in the United States should have the effect of yielding a blue smooth skin.

W. R. Bean, in the *Transactions* of the American Foundrymen's association, has declared that iron oxide in molding sands is detrimental. It would appear to be desirable to have further information regarding both the chemical and physical state of the iron oxide. The washing away of the sand or *scabbing* from the surface of the mold rather points to packing of the pores by silt-grade material.

The chief natural bonds in molding sands thus are ferric hydroxide and clay substance (silicates of alumina, fine micas, etc.). These, like most of the artificial bonds in common use are colloidal bodies, that is, substances exhibiting surface phenomena to a marked extent. Most substances when sufficiently finely divided, can be obtained in the colloid condition. Many colloids are so constituted as to be able to absorb large quantities of water. The plasticity of clays, too, may be increased by an admixture of other colloids such as colloidal silica, alumina, etc. The absorptive power of clay, in the matter of both gases and solutions increases, according to Senfft, with the limonitic content. J. Van Bemmelen found, as long ago as 1878, that the amount of *hydrate water* of ferric oxide was variable and accidental. When just dry at 15 degrees Cent., the compound is able to take up over six molecules of water per molecule of ferric oxide.

These facts throw interesting light upon the bonds of molding sands. One of the most marked characteristics of the best sands is their extraordinary power of taking up considerable quantities of water without really becoming wet. The following figures, for example, are those of hygroscopic water (liberated at 110 degrees Cent.) contained in a few molding sands, some of them moist, but none wet, as collected:

	Per Cent	
Cornish red	11.6	
Erith, strong	10.2	
Belgian yellow	6.6	(Partly dried)
Wolverhampton	13.5	
Kidderminster	8.0	

Another important desideratum of good molding sands, possibly connected with the colloidal character of the bond, is that they should not *go dead,* that is, dehydrate too readily after metal has been cast in them. Iron oxide readily hydrates again, unlike clay, which may be *porcellanized* by heat.

The distribution of the bond in naturally bonded sands is ideal. Each grain of quartz is coated with a thin pellicle of ferric hydroxide or ferruginous clay. Water skins cannot hold on to clean quartz, but each coated grain assumes its skin of water which with its neighbors constitutes the enormously strong, *gluey* bond of the sand.

The effect of milling or mulling of molding sands is well known. Not only are lumps broken down, but the bond is considerably improved. This is doubtless the result of a more even distribution of the binding material around the quartz grains—a result of the rolling and milling action.

It is noteworthy that in west European sands, the higher the percentage of ferric hydroxide, the greater is the transverse strength of the sand. In the case of the sand from South Africa, analyses of which were quoted, containing 4.81 per cent of ferric oxide, the molds produced were of extraordinary strength and toughness.

A final note may be added upon the famous group of British Bunter molding sands, not sufficiently refractory to be used for steel casting, but widely employed in the casting of iron, brass, bronze, etc. The sands, of which well-known examples come from Kidderminster, Birmingham and Mansfield, are of a bright red color, having probably been river-deposited under desert conditions. The sands are fairly well graded and contain little clayey material. Each grain of quartz, however, is evenly coated with iron oxide, in the form of either hematite or limonite. Chemical analysis shows that the actual quantity of ferruginous compounds in the sands are considerably less than would be expected from the deep color of the material. The mechanical and chemical analyses of these sands are given in Tables VII and VIII. The distribution is, however, almost perfect, and the strength of the bond, when the sands are moist, is remarkable.

Table VII

Mechanical Analyses of Bunter Sands

	Per Cent						
	Coarse	Medium	Fine	Coarse	Fine	Coarse	
Birmingham (open)..	0.2	67.1	28.0	1.6	3.1	95.3	
Heck (Yorkshire)....	0.2	77.0	14.7	8.8	0.3	91.9	
Mansfield	4.4	78.8	11.4	0.3	0.9	4.2	94.6
Wolverhampton	trace	27.8	64.6	1.7	1.0	4.9	92.4

Addresses Pittsburgh Section

At the regular monthly meeting of the Pittsburgh section of the Association of Iron and Steel Electrical Engineers, March 15, W. R. Clark, chief engineer, Bridgeport Brass Co., Bridgeport, Conn., read a paper entitled "Applications of Electricity to the Brass Industry." This paper was illustrated with lantern slides.

The firm name of the Lister Sash Weight Co. of Missouri has been changed to The Chemical Foundry Co., St. Louis, Mo.

Table VIII

Chemical Analyses of Bunter Sands

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O+	H_2O-	CO_2	TiO_2	ZrO_2	P_2O_5	SO_3	Cl.	MnO	BaO	Total etc.
Aughton Park, Ormskirk.....	92.30	3.94	0.34	0.15	0.16	0.12	0.03	2.14	0.56	0.34	n. d.	0.19	none	trace	n. d.	trace	trace	0.02	100.29
Belfast, Lagan Vale.....	74.80	7.70	1.13	0.56	1.33	4.55	1.34	2.65	1.18	0.50	3.52	0.30	n. d.	0.04	0.02	trace	0.04	0.04	99.70
Birm'gh'm, Hockley Cem., close	84.86	6.69	1.08	0.35	0.43	0.29	0.40	3.41	1.21	0.55	none	0.40	trace	0.09	none	trace	0.01	0.04	99.81
Compton, nr. W'lverh'pt'n (bulk)	86.37	6.40	0.96	0.25	0.42	0.26	0.36	3.25	1.00	0.57	none	0.35	trace	0.06	none	trace	0.01	0.04	100.30
Heck, near Selby.....	87.14	5.89	1.00	0.29	0.41	0.25	0.14	2.95	1.00	0.55	none	0.18	0.02	0.08	0.03	trace	0.02	0.03	99.98
Kidderminster, Station Pit....	85.66	6.59	0.86	0.36	0.55	0.26	0.16	3.41	1.22	0.74	none	0.40	trace	0.10	none	trace	0.01	0.03	100.35
Mansfield, pig-bed sand.....	88.60	5.40	1.08	0.22	0.28	0.18	0.06	2.49	1.06	0.28	none	0.19	n. d.	none	none	trace	0.02	0.01	99.87
Mansfield, lower medium.....	82.51	4.96	0.97	0.30	1.56	2.39	0.10	2.20	1.29	0.47	0.17	n. d.	0.07	none	trace	0.02	trace	9.93	99.93

Effects of Phosphorus on Malleable Cast Iron

Previously Known and New Reactions of Varying Amounts of Phosphorus in This Material Are Demonstrated Through Comparative Experiments

By J H Teng

IN a paper read before the Birmingham section of the British Society of Chemical Industry, Prof. T. Turner urged the importance of employing a poorer class of irons for malleable castings in view of the heavy demand for purer irons for other purposes during the period of the war. Investigations were undertaken to ascertain the effect of phosphorus, varying in proportions from about 0.05 to 0.5 per cent, on the mechanical properties of malleable cast iron.

It has been stated that irons containing more than 0.25 per cent of phosphorus should not be used for malleable castings, or cracked and warped castings will result. An excess of phosphorus also reduces the melting point, and the castings unable to resist the annealing temperatures show considerable oxidation.

According to Dr. Richard Moldenke the phosphorus content in the American blackheart process does not exceed 0.225 per cent, although Enrique Touceda has shown that a specimen containing 0.325 per cent of phosphorus "is of good quality and sufficiently high grade to be suitable for any purpose for which malleable iron castings may be required." The experiments here described were conducted at the University of Birmingham.

Two series of test bars were prepared, one by adding phosphoric iron to a pure American washed white iron, and the other by adding the same to irons supplied by malleable iron founders in Birmingham.

The composition of the American washed white iron was as follows:

	Per cent
Combined carbon	2.93
Graphitic carbon	0.15
Silicon	0.01
Sulphur	0.004
Phosphorus	0.01
Manganese	nil

This material is hard, white, and highly crystalline, and contains a considerable number of blowholes. The microstructure is typical of a white iron, consisting of pearlite and cementite. Seen under low magnifications, the pearlite is arranged in the finely marked dendritic form, in a ground-mass consisting of pearlite and cementite arranged as a eutectic.

On analysis the commercial irons yielded the following results:

	White iron, per cent	Gray iron, per cent
Combined carbon	2.670	0.440
Graphitic carbon	0.250	3.120
Silicon	0.560	2.200
Sulphur	0.325	0.036
Phosphorus	0.049	0.049
Manganese	0.160	0.580

The mixture used in preparing the second series of bars was one part of gray and three parts of white iron.

The phosphoric iron was prepared by adding red phosphorus to molten American washed white iron. It was hoped to obtain a 5 per cent phosphorus-iron alloy, but owing to loss of phosphorus by volatilization only a 4 per cent alloy was secured. The iron was melted in a plumbago crucible and a weighed quantity of phosphorus was well pressed into small burnt fireclay crucibles. The contents of each crucible was then emptied successively into the molten iron by holding the crucible mouth downwards, so that the rim of the crucible was well immersed in the molten metal. In this way the loss of phosphorus through volatilization was minimized.

The hematite iron ore, used as the annealing medium, was ground to pass a ⅜-inch riddle and then mixed with a certain amount of ore which had been used as a packing material. The proportions of fresh and used ores were dependent on the cross-sectional area of the test bars.

The following table shows the result of the chemical analysis of these ores dried at 100 degrees Cent.:

	Fresh ore, per cent	Used ore, per cent
Ferric oxide	80.539	8.720
Ferrous oxide	.....	58.560
Silica	16.880	18.000
Alumina	1.120	1.440
Lime	0.140	0.200
Magnesia	0.108	0.120

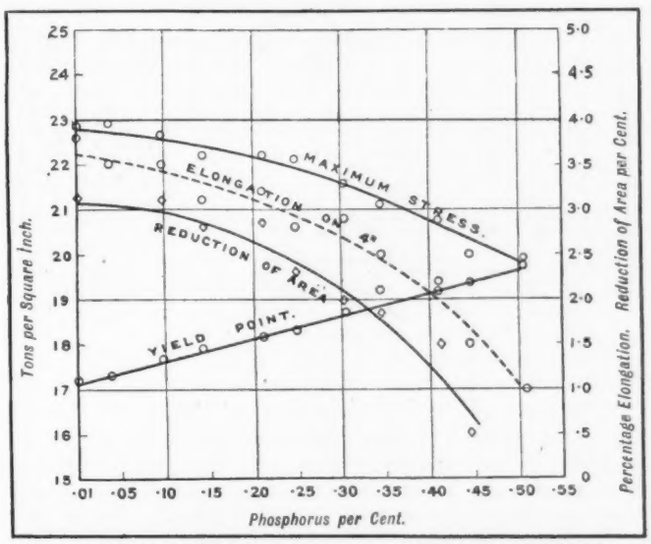


FIG. 1—CURVES SHOWING THE EFFECT OF INCREASING PHOSPHORUS ON TENSILE PROPERTIES OF THE PURE IRON SERIES

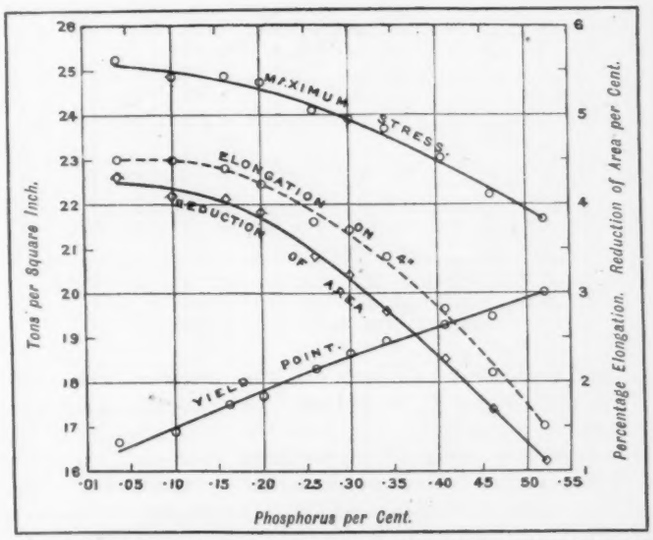


FIG. 2—CURVES SHOWING THE EFFECT OF INCREASING PHOSPHORUS ON TENSILE PROPERTIES OF THE COMMON IRON SERIES

Abstracted from a paper presented at a recent meeting of the British Iron and Steel institute. The author is a research scholar in metallurgy at the University of Birmingham.

Table I

Pure Iron Series

Specimen	Carbon, per cent	Silicon, per cent	Sulphur, per cent	Manganese, per cent	Phosphorus, per cent
A	2.83	0.20	0.0062	....	0.01
B	2.83	0.21	0.0066	....	0.049
C	2.86	0.20	0.0070	....	0.110
D	2.82	0.22	0.0068	....	0.156
E	2.88	0.21	0.0064	....	0.208
F	2.88	0.22	0.0064	....	0.262
G	2.82	0.21	0.0070	....	0.309
H	2.80	0.19	0.0070	....	0.347
I	2.84	0.19	0.0068	....	0.412
J	2.85	0.22	0.0068	....	0.460
K	2.83	0.20	0.0067	....	0.512

Sulphur	0.016	0.342
Phosphorus	0.012	0.017
Manganese	0.432	0.468
Loss on ignition	0.720	.....
Metallic iron	.....	12.105

Tensile, transverse, and bending tests were made. The bars for tensile tests were circular in section; they were 9 inches long, 1½ inches at each end, had a diameter of 1 inch, and the 6 remaining inches at the middle had a diameter of ¾-inch. The bars for transverse tests were 10 inches long by 1 inch square. The bars for bending tests were 9 inches long by ½-inch square.

Duplicate Tests Made

In both series duplicate bars were made to check the result of the testing, and also to replace bars which might contain blowholes or flaws. The weight of each set of test bars, consisting of two bars for tensile, two for transverse, and two for bending tests, was calculated to be about 11 pounds, and to allow for plenty of metal for the gates and runners, 20 pounds of metal was allowed for each set of bars.

The difficulty of obtaining perfectly sound castings with the American washed iron, led to the addition of a small amount of a 25 per cent ferrosilicon to all the casts forming the first series of the test bars. The amount added, however, was not sufficient to give any trace of a mottled fracture to the bars. Further experiments have shown that about 0.25 per cent silicon is the greatest amount that can be added to this iron in the form of round bars of ¾-inch diameter without giving any trace of mottling.

The weighed portion of American washed iron was melted in a plumbago crucible, and when thoroughly melted the calculated amount of ferrosilicon and phosphoric iron was added. After thorough stirring, the contents of the crucible was poured into green sand molds. The bars were cast horizontally in pairs, a runner and a riser being provided for each pair. The melting and casting of all the bars were done under similar conditions. Representative samples of all the casts were obtained from the gate metals for analysis. The chemical analyses of the casts before annealing are given in Table I, shown on this page.

The carbon contents given in Table I are those of combined carbon, since no graphitic carbon was calculated.

Chemical Changes

It will be noticed from these analyses, and the analysis of the American washed iron, that on remelting this iron lost an average carbon content of 0.24 per cent and gained an average sulphur content of 0.0027 per cent.

The chemical analyses of casts before annealing are shown in Table II.

The carbon contents in Table II are those of combined carbon, since no graphitic carbon was obtained.

Representative samples of all the casts were obtained from the gate metals for microscopic examination. The microstructure of all the specimens belonging to the first series of bars was characteristic of a white iron, consisting of bold and well-marked dendrites of pearlite in a ground mass of cementite. Figs. 7 and 8 are photomicrographs of specimens *B* and *K*, respectively. One interesting feature observed in these microsections was that the cementite envelopes in the higher phosphorus specimens appeared to be thicker than those in the lower phosphorus specimens.

The specimens belonging to the second series of bars were similar, except that they showed globules of sulphides

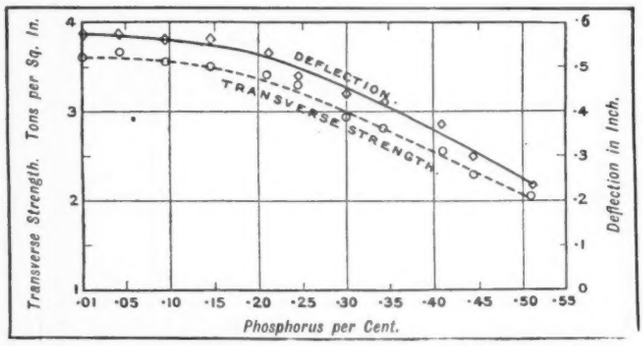


FIG. 3—CURVES SHOWING THE RELATION BETWEEN TRANSVERSE STRENGTH, DEFLECTION AND THE PROPORTION OF PHOSPHORUS IN THE PURE IRON SERIES

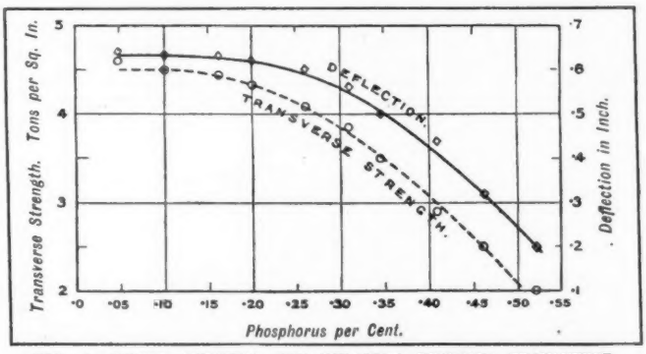


FIG. 4—CURVES SHOWING THE RELATION BETWEEN TRANSVERSE STRENGTH, DEFLECTION AND THE PROPORTION OF PHOSPHORUS IN THE COMMON IRON SERIES

Table II

Common Iron Series

Specimen	Carbon, percent	Silicon, per cent	Sulphur, per cent	Manganese, per cent	Phosphorus, per cent
T_1	2.88	0.815	0.278	0.248	0.048
T_2	2.80	0.810	0.273	0.245	0.106
T_3	2.85	0.820	0.275	0.245	0.160
T_4	2.82	0.820	0.278	0.248	0.208
T_5	2.85	0.820	0.271	0.245	0.263
T_6	2.90	0.816	0.272	0.247	0.300
T_7	2.80	0.815	0.276	0.246	0.344
T_8	2.78	0.818	0.270	0.246	0.406
T_9	2.80	0.816	0.273	0.244	0.460
T_{10}	2.77	0.816	0.275	0.245	0.525

of iron and manganese, which did not appear in the first series. It appears that phosphorus increases the thickness of the cementite envelopes in white irons, irrespective of the chemical compositions, at least so far as those white irons forming the subjects of these experiments are concerned.

The bars were tumbled to remove adhering sand. They then were packed with hematite iron ore in two boxes, and owing to the different dimensions of the bars, the annealing mixture used was varied to counteract the thickness of the different sections. All the specimens were annealed in the same oven.

The following table shows the dimensions of the bars and the corresponding annealing mixture employed:

Dimensions of bar	Annealing mixture: Fresh ore	Used ore
1 x 1 x 10 inches.....	1 part	2 parts
¾ inches diameter x 9 inches	1 part	3 parts
½ x ½ x 9 inches.....	1 part	4 parts

The boxes containing the bars were placed side by side and immediately beneath the thermal junction of a pyrometer, so that the temperature to which the bars were subjected could be known accurately. The annealing oven was rectangular and had a capacity of about 12 tons. It was fired by gas generated in an underground chamber adjoining the oven. A mixture of coke and coal was employed to make the gas. The temperature of the annealing oven was slowly raised to 850 degrees Cent., and this was maintained for four days; then it was raised to 900 degrees Cent., and remained so for one day. The oven was then gradually cooled to atmospheric temperature and the bars were withdrawn.

All the bars were tested with the skin on. The results of the chemical and mechanical tests of the two series of bars are embodied in Tables III and IV, respectively.

Tensile Strength Tests

Tensile tests were made on a 50-ton horizontal machine. It was ascertained that the maximum stress, elongation, and reduction of area are gradually lowered with increasing phosphorus, while the yield point is gradually raised. The most marked effects were observed in bars F and T_s, having about 0.25 per cent phosphorus. These show a distinct drop in the elongation and reduction. The bars belonging to the pure iron series, Fig. 1, show a higher yield point, but a lower maximum stress, a lower elongation and a smaller reduction of area than those belonging to the common iron series, Fig. 2. This difference in the mechanical properties between the two series of bars may be attributed to the influence of silicon, sulphur and manganese which, up to a certain limit, tend to improve the material quite apart from the fact that these elements have important effects on the annealing process.

Transverse tests were made on the horizontal tensile machine. The bars were supported between 8-inch centers. The load and the defleetion were taken when the bars began to fracture. It was found that both the transverse strength and the deflection are steadily lowered with increasing phosphorus. In the pure iron series, the most marked effects are noticed in bar F, with about 0.25 per cent phosphorus. This shows a considerable drop in the deflection, Fig. 3, while in the common iron series no serious drop is observed in the deflection until bar T^s with about 0.3 per cent phosphorus is reached, Fig. 4.

Bending tests were made on the horizontal tensile machine and the angle of bend in each case was measured when fracture took place. The bars were supported between 8-inch centers and were bent around a 1-inch round bar. The bending angle was progressively decreased with increasing phosphorus. Bars F and T_s show a distinct decrease in the angle of bend, as compared with the preceding decreases.

Sections were sawed off the bars in a direction at right angles to their lengths, and parallel surfaces were obtained by machining. These surfaces were ground on emery-paper, then on a set of Hubert papers, and finally they were polished on chamois leather, using alumina. A Brinell testing machine was employed, giving a pressure of 3000 kilogrammes, and having a steel ball of 10 millimetres diameter. The portions tested were at the centers of the sections, and the pressure was allowed to remain on the specimen for 10 seconds in every case, so that the results obtained could be compared.

The influence of increasing phosphorus

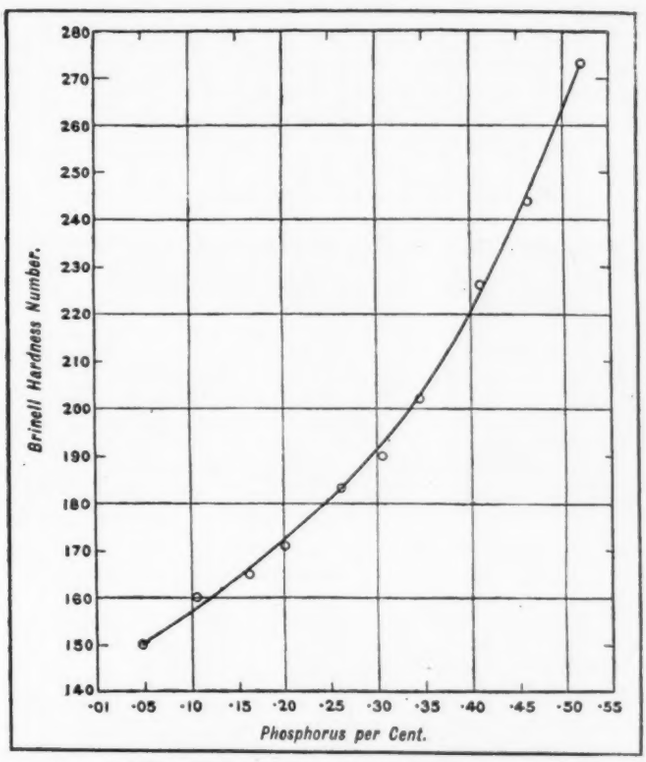


FIG. 5—CURVES SHOWING THE RELATION BETWEEN PHOSPHORUS CONTENT AND HARDNESS IN THE COMMON IRON SERIES

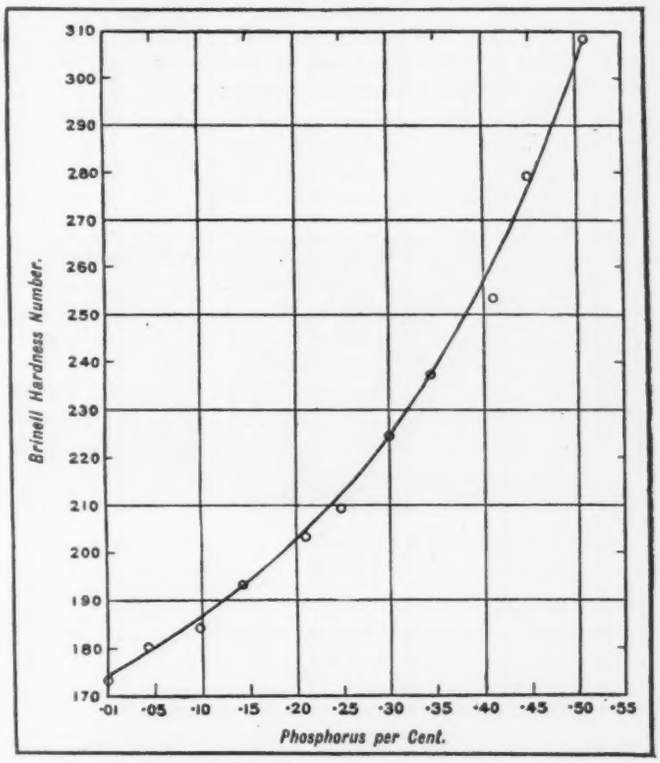


FIG. 6—CURVES SHOWING THE RELATION BETWEEN PHOSPHORUS CONTENT AND HARDNESS IN THE PURE IRON SERIES

Table III

Chemical and Mechanical Tests of Annealed Bars—Pure Iron Series

Mark on Specimen	A	B	C	D	E	F	G	H	I	J	K
Combined carbon, per cent	0.86	0.84	0.80	0.88	0.90	0.85	0.85	0.80	0.89	0.90	0.83
Graphitic carbon, per cent	1.12	1.08	1.10	1.20	1.09	1.10	1.20	1.15	1.11	1.20	1.16
Silicon, per cent	0.204	0.208	0.210	0.204	0.202	0.210	0.205	0.204	0.200	0.210	0.206
Sulphur, per cent	0.007	0.006	0.007	0.006	0.006	0.007	0.008	0.007	0.007	0.006	0.008
Manganese, per cent	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
Phosphorus, per cent	0.010	0.046	0.096	0.144	0.210	0.248	0.302	0.345	0.412	0.446	0.508
Yield point, tons per square inch	17.20	17.30	17.65	17.90	18.20	18.35	18.70	19.20	19.20	19.40	19.80
Maximum stress, tons per square inch	22.85	22.90	22.54	22.20	22.20	22.10	21.56	21.15	20.75	20.10	19.95
Elongation per cent on 4 inches	3.8	3.5	3.5	3.1	3.2	2.8	2.9	2.5	2.2	1.5	1.0
Reduction of area, per cent	3.12	3.00	3.10	2.80	2.85	2.30	2.00	1.85	1.5	0.50	nil
Transverse strength, tons per square inch	3.6	3.67	3.55	3.50	3.40	3.29	2.95	2.80	2.55	2.30	1.80
Deflection in inch	0.57	0.57	0.56	0.56	0.53	0.48	0.44	0.42	0.37	0.30	0.18
Angle of bend	60 deg.	62 deg.	58 deg.	61 deg.	55 deg.	45 deg.	45 deg.	40 deg.	30 deg.	20 deg.	nil
Brinell hardness number	173	180	184	193	203	209	224	237	253	279	308

Drillings for chemical analysis were taken through the middle of all the bars.

on the two series of specimens appears to be identical, Figs. 5 and 6. It increases the hardness steadily at first, and then much more rapidly. The last two specimens of the pure iron series, and the last three specimens of the common iron series are decidedly harder than the preceding specimens. This sudden increase in the hardness may be attributed, at least to a certain extent, to the definite appearance of free phosphide of iron.

Another series of test bars was prepared for Izod impact tests. The composition differed from that of the test bars previously used, so as to confirm, so far as possible, the influence of phosphorus on the annealed specimens. The specimens were packed with iron oxide and annealed under ordinary conditions. Table V shows the results of the chemical tests of the specimens as cast and those of the impact tests of the annealed specimens that were described.

The section of the bar as cast was ½-inch square and, after annealing, it was machined down to ⅜-inch square. A V-shaped notch with a depth of 1/20-inch was made on one side of all the specimens. The results of the impact tests again indicate the ill-effects of any addition of phosphorus.

The structure of all the specimens belonging to the pure iron series consists of ferrite, pearlite, and annealing carbon. The pearlite is rather massive, while the annealing carbon exists in a fine state of division and is fairly uniformly distributed. From the centers toward the outer portions of the specimens the amount of pearlite and annealing carbon decreases, while the amount of ferrite increases until the rims of the specimens are reached, where ferrite alone exists. In the ferrite rims of all the specimens there exists a band of pearlite distinctly sandwiched between two layers of ferrite.

The structure of the specimens belonging to the common iron series consists of ferrite, pearlite, and annealing carbon, and differs considerably from that observed in the pure iron series. In this series the amount of ferrite and annealing carbon is greater, and the amount of pearlite is smaller than those observed in the pure iron series. Furthermore, the carbon nodules are much larger in the common iron series than those in the pure iron series. Fig. 9 is a photomicrograph of specimen T_1, and represents the general structure of the centers of all the specimens belonging to the common iron series. From the centers toward the outer portions of the specimens the amount of pearlite and annealing carbon decreases, while the amount of ferrite

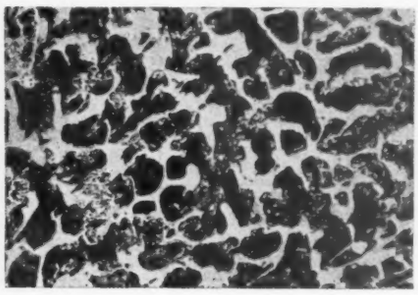


FIG. 7—TEST BAR OF HARD WHITE IRON, MAGNIFIED 100 DIAMETERS

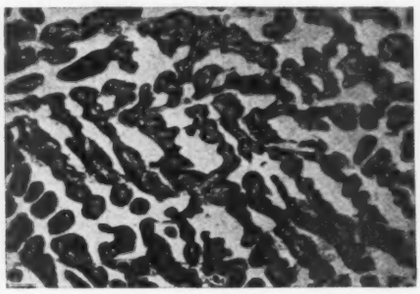


FIG. 8—SAME AS FIG. 7, ETCHED WITH PICRIC ACID

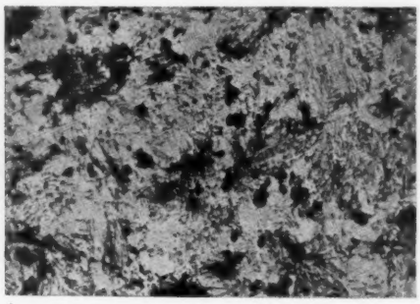


FIG. 9—ANNEALED BARS SHOWING FERRITE, PEARLITE AND ANNEALING CARBON

Table IV

Chemical and Mechanical Tests of the Annealed Bars—Common Iron Series

Mark on Specimen	T_1.	T_2.	T_3.	T_4.	T_5.	T_6.	T_7.	T_8.	T_9.	T_{10}.
Combined carbon, per cent	0.44	0.49	0.40	0.49	0.50	0.45	0.48	0.50	0.52	0.54
Graphitic carbon, per cent	1.76	1.72	1.75	1.62	1.65	1.70	1.62	1.60	1.58	1.59
Silicon, per cent	0.815	0.810	0.817	0.815	0.818	0.818	0.810	0.818	0.816	0.816
Sulphur, per cent	0.278	0.272	0.275	0.275	0.269	0.274	0.276	0.272	0.275	0.275
Manganese, per cent	0.245	0.245	0.248	0.249	0.246	0.245	0.248	0.248	0.244	0.246
Phosphorus, per cent	0.048	0.106	0.160	0.200	0.261	0.306	0.346	0.408	0.461	0.520
Yield point, tons per square inch	16.65	16.90	17.55	17.70	18.30	18.60	18.90	19.35	19.45	20.00
Maximum stress, tons per square inch	25.20	24.85	24.80	24.65	24.10	23.90	23.65	23.00	22.20	21.65
Elongation per cent on 4 inches	4.5	4.5	4.4	4.2	3.8	3.7	3.4	2.8	2.1	1.5
Reduction of area, per cent	4.3	4.1	4.05	3.9	3.42	3.22	2.8	2.25	1.7	1.1
Transverse strength, tons per square inch	4.59	4.50	4.45	4.35	4.10	3.85	3.5	2.9	2.5	2.00
Deflection in inch	0.64	0.63	0.63	0.62	0.60	0.56	0.50	0.44	0.32	0.20
Angle of bend	80 deg.	74 deg.	75 deg.	70 deg.	62 deg.	55 deg.	45 deg.	40 deg.	30 deg.	25 deg.
Brinell hardness number	150	160	165	171	183	190	202	226	244	273

increases, until at the rims, ferrite and sulphides of iron and manganese only exist. The annealing carbon at the center of each section and the manganese and iron sulphides throughout the entire section are distributed with fair uniformity in all the sections. Here, again, a band of pearlite exists in the ferrite rims of all the specimens. According to Sir Robert Hatfield, this band of pearlite generally occurs in a greater or lesser degree in all blackheart malleable castings. It is thus interesting to record that this band of pearlite also occurs in the ferrite rims of the European whiteheart malleable castings. As suggested, it is possible that if the carbon monoxide, produced by the decomposition of the carbide, preponderates, a recarburization might have taken place, but as a matter of fact this outer ring of pearlite is frequently met in annealed castings that have been subjected to an oxidizing atmosphere throughout their heat treatment.

Deep etching of the specimens reveals the gradual increase in the size of the crystal grains from the poor to the rich phosphorus alloys. Thus one effect of phosphorus is to increase the size of the crystal grains.

The fractures of the bending and transverse bars showed peculiar appearances. The fractures of the low phosphorus content bars were partly dull and apparently amorphous, and partly crystalline, while those of the high phosphorus content bars were wholly crystalline. Closer observation revealed the fact that the portions of the low phosphorus content bars, which were subjected to compression, showed a more or less crystalline appearance, while those portions which were subjected to tension showed a dull appearance. This contrast of the appearance of the fractures of the bars gradually disappeared as the phosphorus content increased.

This peculiarity of the fractures led the author to secure a number of specimens from some local works, in order to see, by the appearance of their fractures, whether it was entirely due to the influence of phosphorus or to some other factors as well, with the result that some interesting data were obtained.

Three specimens were obtained from three different local works, and their analyses are given in Table VI.

Table VI

Analysis of Local Specimens

Specimen	Crystalline carbon, per cent	Graphitic carbon, per cent	Silicon, per cent	Sulphur, per cent	Phosphorus, per cent	Manganese, per cent
A	1.20	0.75	0.780	0.328	0.048	0.210
B	0.76	1.26	0.541	0.164	0.049	0.288
C	0.62	1.45	0.648	0.247	0.065	0.365

These specimens which were nearly of the same thickness, were fractured on the vise by bending a 1-inch round bar, and the fractures examined. Results of bending tests were as follows:

Specimen	Bending angle
A	45
B	80
C	150

The results of these tests, although not strictly comparable, since the sections of the specimens are not exactly the same, are nevertheless a measure of the malleability of the specimens.

Table V

Chemical Tests of Specimens

Mark on Specimen	Carbon, per cent	Silicon, per cent	Sulphur, per cent	Manganese, per cent	Phosphorus, per cent	Impact Tests, Ft. lbs.
T_1	2.96	0.586	0.442	0.208	0.06	8.5
T_2	2.80	0.570	0.460	0.200	0.115	8.00
T_3	2.92	0.585	0.454	0.195	0.165	7.25
T_4	2.75	0.580	0.445	0.210	0.220	6.50
T_5	2.80	0.575	0.440	0.201	0.258	6.00
T_6	2.92	0.582	0.450	0.205	0.322	5.00
T_7	2.70	0.580	0.430	0.199	0.362	4.25
T_8	2.74	0.576	0.462	0.210	0.410	3.75
T_9	2.92	0.580	0.452	0.204	0.465	3.00
T_{10}	2.90	0.572	0.452	0.206	0.530	3.00

The results of the examination of the fractures of the specimens are given in the following table:

Specimen—Compression side	Appearance of Fracture—Tension side
A—Slightly crystalline	Dull
B—More crystalline	Dull
C—Highly crystalline	Dull

It appeared from the fractures that the more malleable the specimen, the greater will be the contrast in appearance between the compression and tension sides. This is due to the greater amount of ferrite. A consideration of the behavior of the crystals of a ductile material, which is partly under tension and partly under compression, will show that the results of this observation are to be expected. The crystals on the tension side are drawn out, so to speak, at their ends; while those on the compression side will be flattened out, and having a certain amount of soft material to fall back upon these crystals will show their crystalline faces in a direction at right angles to which the force is applied.

It is thus apparent that a hard and brittle material when fractured by bending will not exhibit the characteristic combination of crystalline and dull fracture. Here an explanation may be found for the wholly crystalline fractures of the high phosphorus content bars referred to previously. The results of the mechanical tests of the bars appear to support this view.

In order to reveal the distribution of phosphorus in the annealed bars, sections after careful repolishing were treated by Dr. J. E. Stead's copper reagent. The reagent was dropped on each section until the section would hold no more, and then allowed to stand for two minutes. The sections were all treated alike and for the same period. After washing the sections with boiling water, and then with methylated spirit, they were carefully dried and examined under the microscope.

The results of micro-examination of sections belonging to the pure iron series were as follows:

From sections *A* to *K* the thickness of the copper deposits decreased gradually, while the proportions of the number of areas which remained bright steadily increased. The ferrite in the immediate vicinity of the annealing carbon nodules remained bright. But as the phosphorus increased, some of the ferrite also received a copper deposit.

Sections belonging to the common iron series also showed a progressively decreasing thickness of copper deposit from section T_1 to section T_{10}. Here again the ferrite in contact with the annealing carbon nodules was free of copper deposit, and as the phosphorus contents increased, some of the ferrite was also covered with copper.

It was thought that oxidation had

taken place in the high phosphorus content specimens, and that the oxide of iron so formed in the crystal boundaries led to the deposition of copper in these areas. Specimen T_{10}, containing the highest phosphorus content in the common iron series, therefore, was heated at a temperature of about 750 degrees Cent. for 42 hours in a stream of coal gas, the cooling taking place in the same gas. After this heat treatment the specimen was repolished and treated with the copper reagent in exactly the same manner as before. No difference in the copper deposition was observed, and hence it would seem that the peculiar way in which the copper deposited on the high phosphorus content specimens was not due to the oxidation of the specimens, but must be attributed to the distribution of the phosphorus.

Origin of Sulphide Sought

An attempt was made to trace the origin of the sulphide of iron which is invariably found in the iron ore that has been used as the annealing medium in the production of malleable castings. R. H. Smith has indicated that the white irons which are being annealed in an iron ore do not lose their sulphur content, no matter whether these irons are low or high in sulphur. Hence the origin of the iron sulphide must be sought for elsewhere. The sulphur content of the fresh ores generally used in this district does not exceed about 0.02 per cent, whereas the sulphur content of the used ores sometimes reaches to 0.3 or 0.4 per cent. In the earlier part of the present paper the analyses of the fresh and used ores were given, from which it will be noted that the sulphur content of the fresh ore is 0.016 per cent, while that of the used ore is 0.342 per cent. Subsequent analysis has shown that 0.096 per cent of the sulphur in the used ore exists as sulphide of iron. Professor Turner concluded that the presence of this sulphide was derived from the action of the reducing gases existing in the furnace at a temperature of about 900 degrees Cent.

The following experiments were undertaken to see whether this sulphide of iron was really due to the reducing character of the atmosphere in the annealing furnace. Pieces of pure American washed white iron and of common sulphurous white iron were packed with fresh hematite iron ore in two separate fireclay crucibles. The lids were luted on the crucibles. They then were placed in an oxidizing annealing muffle-furnace, and a temperature of 900 degrees Cent. was maintained for 72 hours. After the heat treatment the ore was ground down to a fine state of division and found to be magnetic. Minute pieces of metallic iron, which had been apparently flattened out by the grinding, could be seen.

The ore was analyzed for sulphide of iron and metallic iron. No trace of sulphide of iron could be found, although 1.56 and 1.42 per cent of metallic iron, respectively, were obtained from the two samples of ore. These results appear to show that no sulphide of iron is formed in the spent ore when the atmosphere of the annealing furnace is oxidizing in character.

To confirm the laboratory results, samples of gases in the works annealing furnace were obtained at a temperature of 900 degrees Cent. Two samples were obtained, one at 11 a. m. and the other at 4 p. m. on the same day. Results of the gas analyses follow:

	Sample I, per cent	Sample II, per cent
Carbon dioxide	14.17	12.30
Carbon monoxide	6.78	7.42
Oxygen	4.00	3.45
Hydrogen	2.12	2.86
Methane	0.58	0.75
Sulphur compounds	0.20	0.25
Nitrogen	72.15	72.97

The results of the analyses of the two samples of furnace gases appear to support Professor Turner's view with regard to the origin of sulphide of iron in the spent ore. It should be mentioned that these samples of gases were not obtained inside the boxes where the bars were imbedded, but an explanation may be found for the action of these gases upon the annealing oxide. It is certainly probable that the luting material, with which the boxes were rendered airtight, gave way at the high temperature of the annealing furnace. Thus portions of it were detached or cracked, and the furnace gases obtained access to the boxes in which the castings were embedded.

Conclusions Drawn

The following conclusions may be drawn from the results of the foregoing experiments:

The addition of phosphorus does not result in any improvement in the mechanical properties of the malleable casting.

Any addition of phosphorus leads to a deterioration in the mechanical properties, as shown by tenacity, elongation, and toughness.

The ill effects of phosphorus do not become marked until about 0.2 per cent of phosphorus has been reached, and this may be considered to be the approximate limit for commercial purposes.

That the presence of a considerable amount of silicon and manganese is of more importance than the absence of sulphur with regard to the success of the annealing operation.

That the origin of the sulphide of iron in the spent oxide is attributable to the presence of sulphur compounds in the reducing atmosphere in the furnace near 900 degrees Cent.

Metropolitan Brass Founders' Association Organized

To standardize nonferrous metal foundry practice, a number of the larger manufacturers of brass, bronze and other nonferrous metal castings in the greater New York district formed the Metropolitan Brass Founders' association. Members of this society claim that a great need exists for such an organization, pointing to the unusually large number of business mortalities among the nonferrous metal founders. They explain that this results from the ignorance of many foundrymen of their real costs. It is claimed further that the capital needed for establishing a brass foundry business is not large in comparison to other branches of the casting industry and consequently many new foundries are established every year. Some of them do not last 12 months, but their methods of doing business before they fail work a great hardship on the efficiently conducted plants which are compelled to meet their competition. The by-laws of the association show that it was formed for the following objects:

To advance the interests of those engaged in the manufacture of brass, bronze or nonferrous metal castings and to promote free discussion of subjects relating to the industry.

To give due consideration to the welfare of employes, with a view to just treatment under prevailing trade or economic conditions.

To disseminate technical information among its members relating to foundry practice.

To expose unfair methods of competition, to endeavor to standardize the various grades of metal and to cooperate for the good of the industry.

The by-laws of the association state that they shall not be construed as directly or indirectly restraining the freedom of any member in quoting on his products and further specify that no member is to enter into any agreement which will restrain trade, limit competition or regulate prices.

The Metropolitan Brass Founders' association now has 27 brass founders enrolled and its membership list is open to other nonferrous metal foundries within 50 miles of New York. Regular meetings are held the second Wednesday of each month, in the Building Trades building, West Thirty-fourth street, New York. F. H. Landolt, of the Penn Brass & Bronze Works, Brooklyn, is chairman, and W. H. Paulson, 97 Second avenue, Brooklyn, secretary.

Making Quad Wheels in a Tractor Foundry

Fig. 1—Wheel Casting as Shaken Out of the Mold

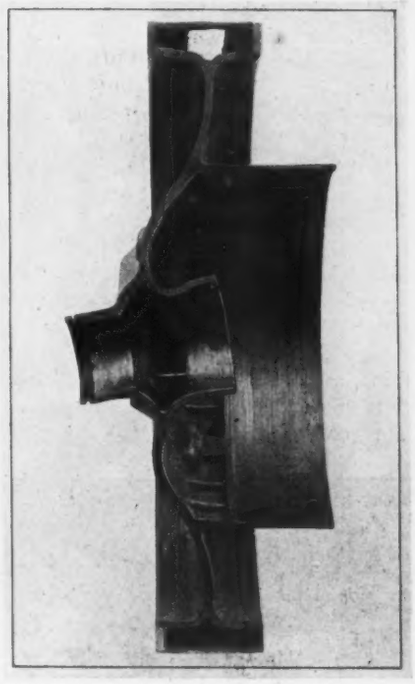


Fig. 2—Sawed Section of Wheel Tested to Destruction

STEEL wheels manufactured for the four-wheel-drive trucks ordered by the army for the quartermaster's and other departments involved many foundry difficulties. The Hart-Parr Co., Charles City, Iowa, was not a novice in the production of steel castings. It was one of the first to enter the field of tractor manufacture and its steel foundry, since 1908, produced not only motor frames, wheels and other parts required for its line of tractors, but also found opportunity to handle commercial steel casting. This all contributed to its wide experience. When the government, through its various truck contractors, called for thousands of steel truck wheels, this company was one of the first to take up the work.

Lightness, toughness, and above all freedom from blow-holes and those under surface defects sometimes encountered in thin steel castings, were demanded. A glance at the illustration, Fig. 2, which shows a wheel tested to failure and then sawed, conveys an idea of the thin sections encountered. The brake drum in particular was a source of trouble. The four-wheel-drive truck drives on all four wheels, as its name implies. For this reason every wheel had this drum. It was found that in casting under the earliest systems employed, this drum was filled with pinholes. Furthermore, shrinkage in the rim of the wheel added to the chances of defective castings. Foundry commonsense in molding overcame these troubles.

The practice developed by the Hart-Parr Co. foundry was devised to get greater production with a minimum of pattern equipment and labor. As the work was undertaken to meet a war emergency, no molding machine equipment was installed. In the early stages of wheel casting manufacture, 12 pattern sets were employed. With succeeding changes in design, the complete substitution of new pattern equipment involved expense and great delay. The final system which was in operation at the time of the armistice required only four sets of patterns and four simple vibrators manufactured by the Adams Co., Dubuque, Iowa. These all are the type shown in

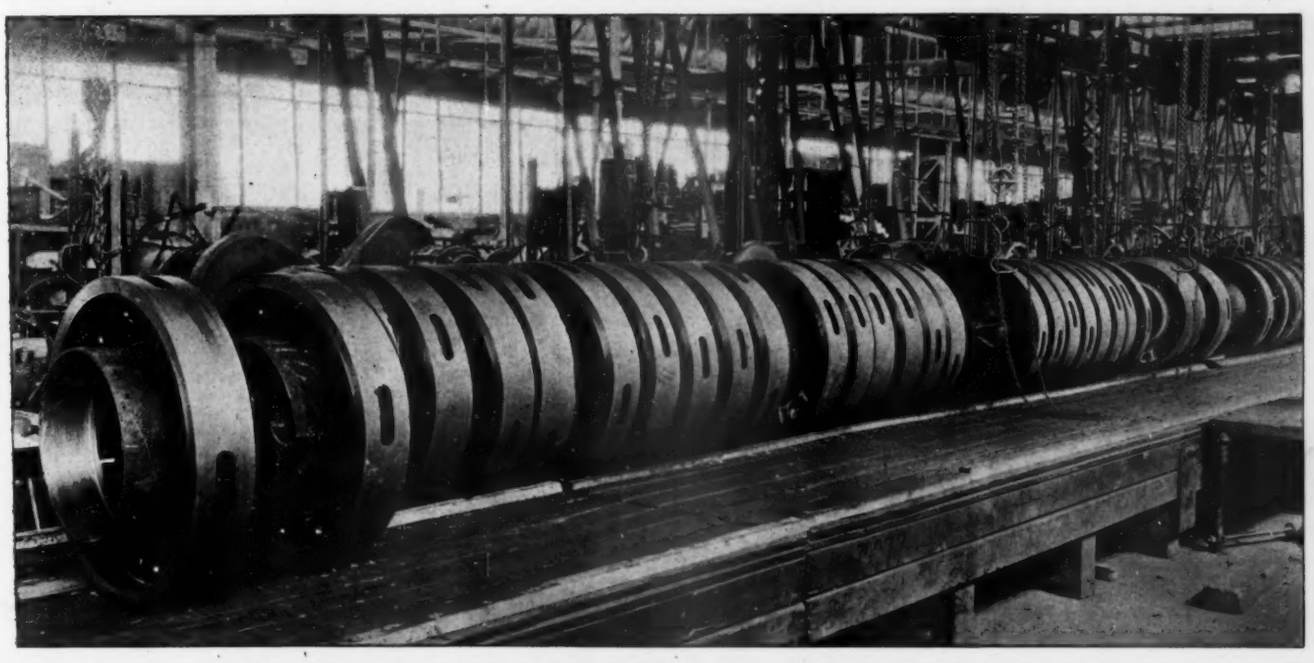


FIG. 3—COMPLETED WHEELS AFTER MACHINING—SHELL LATHES WHICH HAD BEEN USED ON BRITISH SHELL ORDERS WERE ADAPTED TO THE MACHINING OPERATIONS REQUIRED ON THESE WHEELS

Fig. 4. Four separate layouts were provided for this work. These were operated as individual units, by two shifts of molders; one shift working from 4 a. m. to noon and the other from 1 to 9 p. m. Three men comprised the molding force which operated each unit; one man molded the cope, one the drag and the third set the cores; the latter, with the aid of a laborer, closed the mold and delivered it to the crane on the main floor. Thus each molding unit was in charge of six men during the double shifts, and an average of over 30 complete molds per unit was maintained. The output reached 150 complete molding stations in bins holding about ½-cubic yard, and equipped with hooks for ease in crane handling. Backing sand was piled on the side away from the trackway in floor piles, but within shovel-reach of the molders.

The speed attained in the production of the molds is remarkable when the intricacy of the job is considered. Fig. 2, which shows a section through the wheel, and Fig. 3, which shows a number of the wheels delivered on a table for machining, gives an idea of the accuracy necessary. Aluminum patterns were employed for the cope except for the small cylinders used in forming the risers. These patterns were made by outer rim to the edge of the cylindrical box into which the outer hub of the wheel pattern extended. Spaced evenly between these full webs were short webs extending out half way to the center from the rim. These, with gaggers used in each of the intermediate spaces, formed a solid support for the sand forming the cope half of the mold. The central cylindrical box was extended high enough so that the risers gained an additional head of metal when poured.

Molds Made Rapidly

Drags and copes were rammed simultaneously. A slightly greater amount of time was required for the cope,

FIG. 4—COMPLETE PATTERN ASSEMBLY FOR MAKING CAST-STEEL *QUAD* WHEELS BY THE METHOD DEVELOPED AT THE HART-PARR FOUNDRY, CHARLES CITY, IOWA

wheels per day, shortly before the end of the war. This production was made possible by the rivalry which developed between the different crews and they were spurred on further by being paid on the basis of perfect molds completed.

Four Layouts Employed

The four molding units were located in pairs, two each on the two side bays along the main molding floor. The drag patterns were set up in a definite station and beside this location was the frame upon which the copes were molded. Parallel to these two stations was a trackway upon which was mounted a simply constructed platform car capable of holding six completed molds. Facing sand was delivered to an accessible point between the two the Hart-Parr Co. and were provided with a brass crushing strip where there was danger of bumping or marring the pattern. The main drag pattern shown at *A*, Fig. 4, was wood, mounted firmly upon a pattern board. The ring pattern which formed the brake drum is shown at *B* in the same illustration, while *C* formed the print for the gate core which will be described later. The aluminum pattern mounted in the top plate of the vibrator frame is shown at *D*, while four small cylindrical patterns, similar to *E*, upright on the frame of the vibrator, were used to form the risers in the cope.

Special flasks were made for this work. The one employed for the cope was provided with eight main web divisions extending through half the thickness of the flask, and running from the which allowed the drag to be in place and the cores set before the cope was ready. The sequence of operations in molding did not vary in any particular from day to day. The drag pattern, face up, was firmly bedded in the floor. The brake drum ring pattern and the runner print pattern were set in place. The drag flask, a plain circular flask with an upper and lower flange, then was fastened rigidly in place by two binding screws, one of which is visible in Fig. 5 at *F*. Facing sand was distributed over the entire pattern and was tucked around the outer circumference of the wheel and the brake drum ring. Backing sand was then filled-in and firmly molded with a pneumatic rammer. A second layer of sand finally was added and the surface rammed firmly. The top then was swept level. The

FIG. 5—THOROUGH VENTING, PARTICULARLY AROUND THE BRAKE-DRUM, PROVED THE REMEDY FOR PIN-HOLES IN THE CASTINGS—THE SPECIAL COPE FLASK IS IN THE FOREGROUND

molder next made two rough channels across the surface to supply a conducting path for the escape of gases. The template, shown at *G*, Fig. 5, was then put in place. This template was the solution of the problem of pinholes which developed in the brake drums when the castings were poured regardless of the temperature of the metal.

The two rings of the template covered the portions of the mold in which were located the brake drum and the outer rim of the wheel. The space left between was an instant visual guide to the molder in venting the mold. The venting between these rings was thorough. Molders were instructed that they were to form all the vents they could and then to add a few for good measure. Rapid molding under the piece-work system might have led some to slight this feature, but the use of the template and the assurance that a passing foreman by a glance could tell whether the mold had been sufficiently vented exerted a psychological effect. It was stated that from the time the template was first used, no trouble was experienced due to slighting this important part of the molding.

The bottom boards used were machined to fit the flasks and provided with under surface ridges upon which they rested. The gas channels, together with a system of holes located around the under side, permitted the free escape of gases from the drag. After ramming, the bottom board was wedged in place. The mold then was rapped and picked up by means of a small crane which engaged the lugs provided on the sides of the flask. The brake drum and gate patterns remained in place. The mold then was swung over, face up, on the platform car. Here the brake drum pattern and the gate core print pattern were drawn and the cores were set.

Thirteen cores were required in the

FIG. 6—COMPLETED GREEN SAND MOLDS ON THE PLATFORM CAR—THE DRAG MOLD, AT THE LEFT, REQUIRES 13 CORES

casting as made by the company during the early winter. The *skirt* or rim core, provided to form the hollow rim, was in four sections. Three inner cores fitted together to form the internal gear band. Four cover cores set into the recesses shown in the outer circumference of the drag, Fig. 6, formed the openings in the outer wheel rim, which may clearly be seen in Fig. 3. The hub and gate cores completed the assembly ready for the cope. The gate core was set in the print shown in Fig. 6. This core was formed with a slotted lower opening which delivered the metal to the bottom of the mold, allowed it to flow around the outer rim and into the brake drum, hub and other parts of the wheel. Liberal risers at the hub and at two points in the rim were provided. The two risers on the rim, each 2 inches in diameter, may be noted on the completed casting, Fig. 1. These risers eliminated the shrinkage difficulty.

The molding of the cope required a slightly longer time. The special flask described was set upon the upper frame of the vibrator, which constitutes a pattern board into which the pattern is sunk, as shown in Fig. 4. The flask was set, and fastened by binding screws. Facing sand was riddled over the face of the pattern before the flask was set. The pouring gate pattern was then set and backing sand filled in to about one-half the depth of the flask. Eight gaggers were set in the spaces between the inner braces of the flask and the patterns for the two hub risers and the two rim risers were placed in position. The flask next was filled with backing sand and tucked. The rim risers each extended about 45 degrees around the circumference in each direction from the gate pattern. The entire mold then was rammed firmly except in the center, which was not rammed hard. The top was then leveled and the vibrator set in operation. The same crane which served the drag pattern then drew the mold, swung it over to the platform car where the drag was ready and closed the mold.

Mutual Pace-Setting

Perfect relation and co-ordination between the various operations enabled the molding crews to keep pace with one another. When the six molds were completed, the car was pushed forward to the edge of the main molding floor where one of the main traveling cranes conveyed each in turn to a point convenient to the open-hearth furnaces. The steel foundry employed five cranes continuously in addition to a number of air hoists. Two 15-ton girder cranes built by the Pawling & Harnischferger Co., Milwaukee, and a 15-ton crane of similar type manufactured by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y., served the main floor. Two five-ton overhead cranes built by the latter company were operated over the two side bays as auxiliaries.

Four men were employed in the core department to take care of the needs of wheel production. Two of these men worked on rim cores alone, while the others made the hub, pouring gate, gear and cover cores. The cores were hand-made from sand mixed with a pitch binder. Two car-type, coke-fired ovens provided drying facilities for the steel foundry. Sand was mixed by a 9-foot pan, ¾-yard mixer.

Steel was required to meet the navy "B" specification, which analyzed about 0.25 per cent carbon and 0.60 to 0.80 per cent manganese. Two 10-ton basic open-hearth furnaces provided two heats each every 24 hours. The furnaces were built by the Whiting Foundry Equipment Co., Harvey, Ill. They were equipped with flues along the bottom and up the sides and were fired by billow-type oil burners. Oil was stored in a 60,000-gallon supply tank and a 325,000-gallon reserve reservoir assured against emergency shortage. Oil was metered to each furnace, and was preheated by electric heating coils before delivery to the burners.

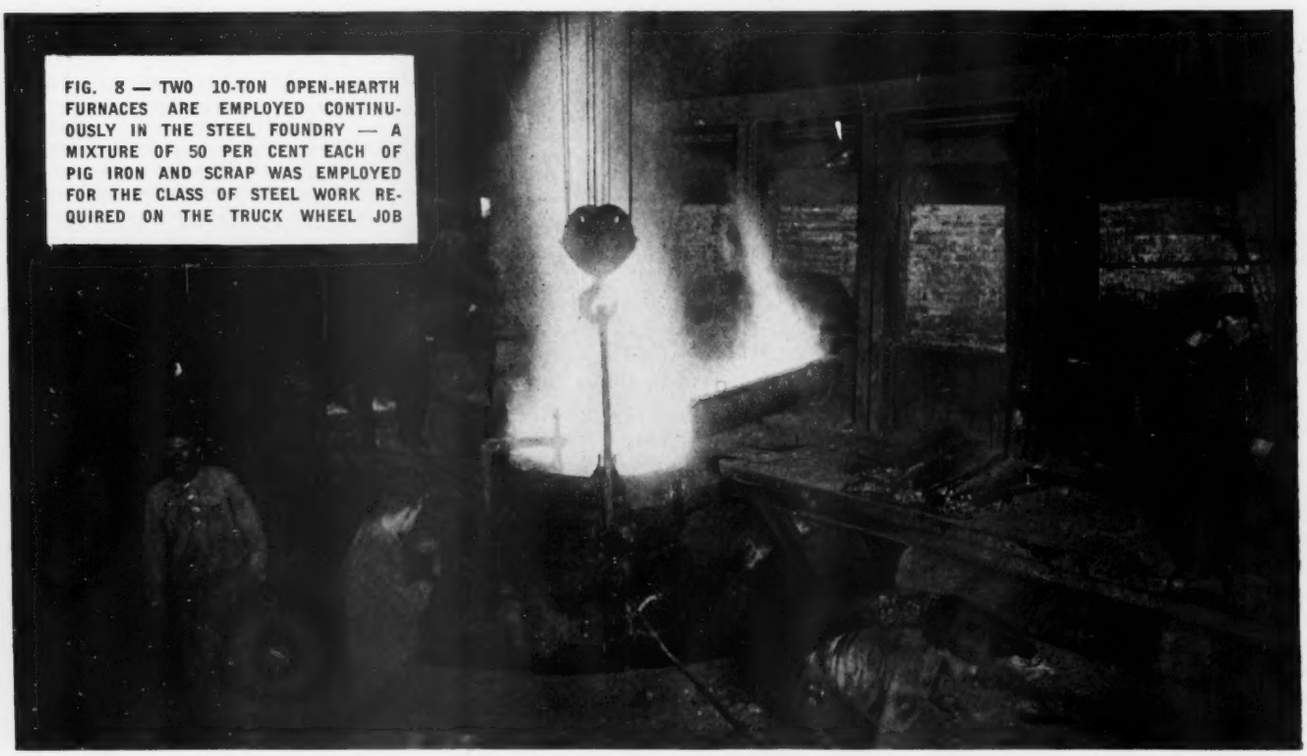


FIG. 8 — TWO 10-TON OPEN-HEARTH FURNACES ARE EMPLOYED CONTINUOUSLY IN THE STEEL FOUNDRY — A MIXTURE OF 50 PER CENT EACH OF PIG IRON AND SCRAP WAS EMPLOYED FOR THE CLASS OF STEEL WORK REQUIRED ON THE TRUCK WHEEL JOB

All molds in the central aisle were cast from bottom-pour ladles. Great care was exercised to assure a high temperature in the metal at pouring. The temperature found most satisfactory in the case of the steel wheels was in approximately 3000 degrees Fahr. Furnace crews, pouring and shake-out gangs worked on shifts 24 hours daily. Sufficient molds were made in the two 8-hour shifts to make this operation possible. Forty molders, all but two of whom had been trained and developed in the company's foundry, provided the molds which 110 additional men poured, and shook-out and prepared the castings for the cleaning room.

The cleaning room absorbed not only all the work from the steel foundry,

but also that from the gray iron foundry of the same company. Its equipment included two tumbling mills, a high pressure sand-blast, six oxyacetylene welding torches made by Davis-Bournonville Co., Jersey City, N. J., and an electric welding room equipped by the Lincoln Electric Co., Cleveland. The steel wheel casting, after the gates and risers were removed, weighed about 275 pounds. It was cleaned and afterward machined until its finished weight was about 230 pounds. The wheels were annealed by being slowly heated to 1600 degrees Fahr. in a furnace where they were allowed to soak two hours and cooled before removal. Two oil annealing furnaces, each with a capacity of 80 wheels, were employed.

The war work of the Hart-Parr Co. interfered with, but did not supplant entirely, its tractor business. For this reason the tractor castings required were produced by the steel foundry with its war work. In addition to the wheel order, a large navy contract for gun mounts and slides was in progress. This job occupied a part of the main floor. Still another portion was devoted to crawler sprockets for artillery caterpillar tractors. These were simple, 26-inch sprockets with sections which involved little difficulty in molding. The fact that the company made the most of its existing equipment suffice, and so co-ordinated its force to war work, contributed largely to the ease with which it returned to a normal basis of production.

New England Supply of By-Product Foundry Coke

The Providence Gas Co., Providence, R. I., has begun operations at its new by-product coke oven plant. The daily carbonizing capacity is 750 tons of coal from which it is estimated 500 tons of coke will be obtained. A mixture of high and low volatile coal will be used and each oven will take a charge of 114 tons. The plant, which consists of one battery of 40 ovens of the cross, regenerative, combination type, was constructed by the H. Koppers Co., Pittsburgh. The Providence Gas Co. intends to specialize in the production of foundry coke and to guarantee sulphur and ash contents under 1 per cent and 10 per cent, respectively. The entire production will be under the management of W. G. Rich, general sales agent of the company.

Edgar E. Durant has purchased the entire property of the G. F. Warner Mfg. Co., New Haven, Conn., and will operate the plant under the firm name of the G. F. Warner Mfg. Works. This plant is engaged in the making of gray iron castings.

Reports on Aluminum Solder

Solders and methods of soldering aluminum recently have formed the basis for investigation by the bureau of standards. In a circular on this subject it is stated that all metals used for aluminum soldering are electrolytically negative to aluminum. A soldered joint for this reason is attacked by electrolysis and destroyed when exposed to moisture. For this reason it is recommended, unless repairs are heavy, as in the case of large castings, that the soldered joint should be protected by paint or varnish.

Solders should be applied without a flux after preliminary cleaning and tinning of the surfaces to be joined. The solder should consist of a tin base with an addition of zinc, or zinc and aluminum. The function of the alloys is principally to produce a fluid mixture within the range of soldering temperatures. A high temperature is advised to secure adhesion of the tinned surface. The following compositions are suggested:

Tin-zinc solders:	
Zinc, per cent	15–50
Tin	Remainder
Tin-zinc-aluminum solders:	
Zinc, per cent	8–15
Aluminum, per cent	5–12
Tin	Remainder

By using the higher values of the zinc and aluminum percentages, the solder will be too stiff at the lower temperatures to flow readily. A higher temperature will secure a better joint. Good aluminum solder should not be brittle. The tensile strength of the better grades of aluminum solder is about 7000 pounds per square inch. The strength of the joint, however, is dependent upon the workmanship.

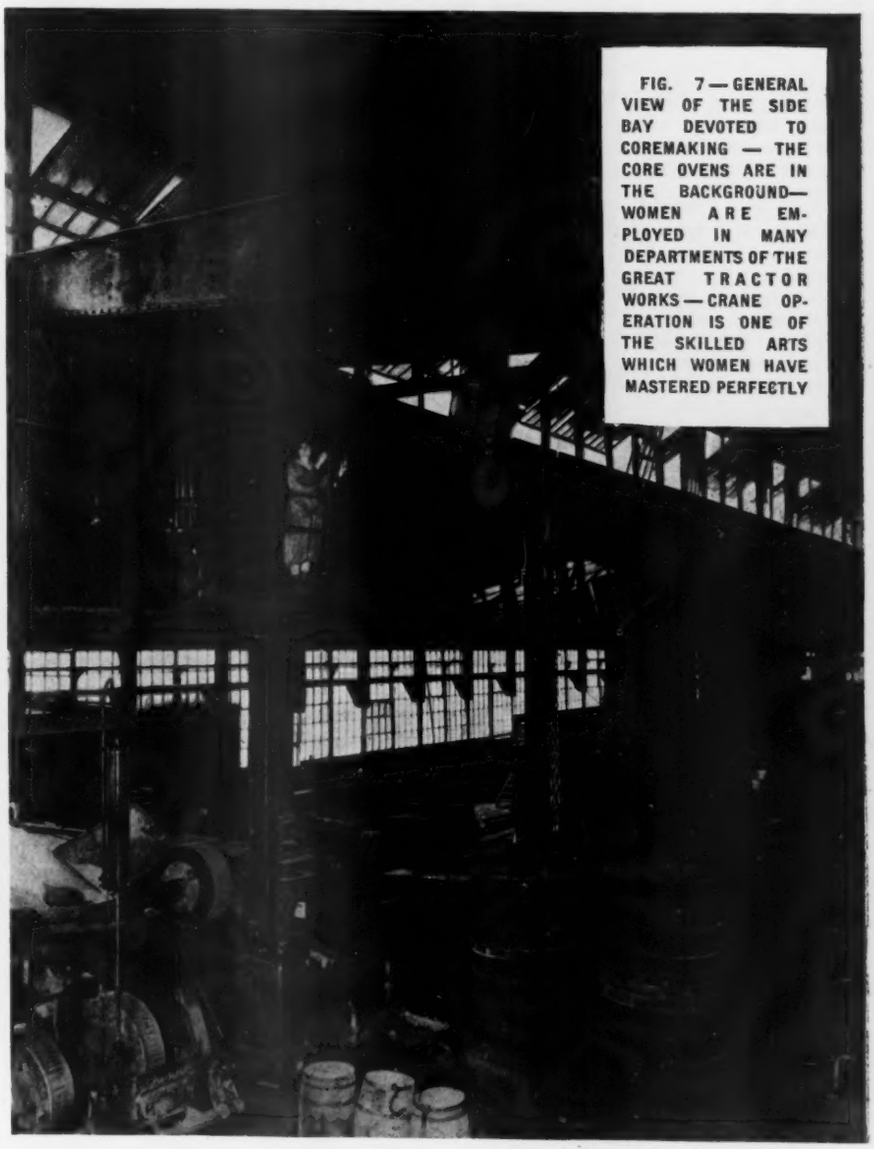


FIG. 7—GENERAL VIEW OF THE SIDE BAY DEVOTED TO COREMAKING — THE CORE OVENS ARE IN THE BACKGROUND—WOMEN ARE EMPLOYED IN MANY DEPARTMENTS OF THE GREAT TRACTOR WORKS—CRANE OPERATION IS ONE OF THE SKILLED ARTS WHICH WOMEN HAVE MASTERED PERFECTLY

The New York branch of the Independent Pneumatic Tool Co., Chicago, will be removed March 1 from 170 Broadway to 1463 Broadway, where larger quarters are available.

Casting Cutting Tools from Crucible Steel

New Process Produces Dead Steel of High Fluidity for Tool Castings That Require Finishing Only on Cutting Edges

By J E Johnson Jr.

SINCE the invention 18 years ago by Taylor and White of a process of heat-treating steel tools, the production of metal-working tools has been revolutionized. This was an exceedingly important invention, although it consisted principally in establishing the fact that, while overheating, when it accidentally occurred in the ordinary process of forging, spoiled the steel, it resulted in imparting a cutting power several times as high as had ever been obtainable before, if carried much farther or to a point that would have been considered absolutely ruinous to the steel under the old ideas.

The quality that gives the steel this power eventually received the name of "red hardness." This name originated in the fact that tools possessing this property retain their resistance to deformation even when subjected to such severe cutting stresses that the metal just back of the point is heated under certain conditions to a visible red. It is interesting in this connection to note that the edge of the tool itself does not become red because it is continually cooled by the fresh metal into which it is forced.

The result of Taylor and White's invention was an intensive study of tool steels all over the world and, although there was a great diversity of analysis in the high-speed steels of the early days, these steels today generally have an approximately similar composition, the principal constituents being from 15 to 20 per cent of tungsten, from 4 to 6 per cent of chromium, from 1 to 2 per cent of vanadium, and from 0.50 to 1 per cent of carbon. It is probably safe to say that standard brands of such high-speed steels will do from five to ten times as much work in a given time as the carbon steels, and even the mushet steels, which were the sole dependence up to the beginning of this century, when the Taylor-White process was discovered. With the increasing cost of labor, it is not surprising that these steels have driven from the market, for all but limited purposes, the older types of steel.

Conquering Old Fetishes

These types of steel are harder and more difficult to work than ordinary carbon steel. It was for several years considered impossible to weld them at all and, while this can be done now, it is not a process that commends itself to the best toolmakers. For the ordinary run of tools made from straight bars, such as those used for lathes, planers and shapers, the processes of manufacture have not been much more difficult and expensive than the same processes for the older tools, the steel being cast into small ingots and then rolled or hammered to bars of the desired section, from which the desired form of tool is produced by forging and grinding a cutting edge on one end. For formed tools, such as milling cutters, large drills, countersinks and other shapes that do not lend themselves to production from the straight bar, the conditions are different from those obtaining when carbon steel is used.

In the first place, the expensive alloys, tungsten, chromium and vanadium, that must be liberally used to produce these tools make the cost of the molten metal many times higher than the cost of the carbon steel of old. Under the conditions prevailing in recent years the difference can almost be expressed in terms of dollars per pound for the new product instead of cents per pound for the old. Second, the production of a milling cutter or similar formed tool by existing methods is an expensive operation. First a blank of suitable size must be produced by forging an ingot, or large bar, and if the cutter is at all large, a bar of extra large size must be produced in order to make it. After forging, the rough blank is annealed and then sent to the tool room for machining. This must be done with great care and accuracy, and usually involves a multiplicity of operation, since the formation of each tooth involves several cuts. The labor that does this work is deservedly the highest priced mechanical labor we have today, and its speed is necessarily limited for the reason that in forging, which is a rough operation, much stock must necessarily be taken off in the production of formed cutters, and the stock to be removed is far harder and more difficult to machine, even after thorough annealing, than was old-fashioned carbon steel.

The production of formed tools by these methods is extremely expensive, for two reasons: First, a large percentage of the weight of the forged blank must be cut away, resulting in chips of fractional value as compared with the value of the forged steel. Second, the labor involved in machining the tool to shape is great in amount and expensive in quality.

At different times in the last two or three years, various people have conceived the idea of casting tools to

From a paper presented at a meeting of the American Institute of Mining Engineers, New York. The author, J. E. Johnson Jr., is a consulting engineer and metallurgist, New York.

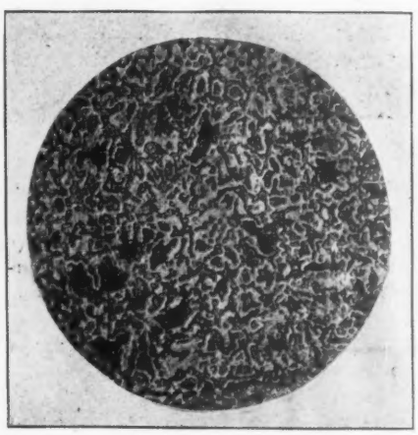


FIG. 1—SECTION OF CUTTER MADE BY THE DAVIDSON PROCESS, ETCHED IN 5 PER CENT NITAL SOLUTION FOR 30 SECONDS. X 100

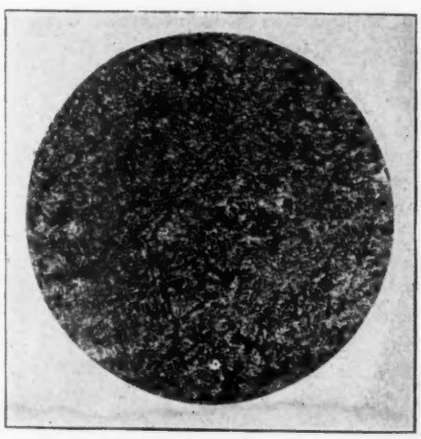


FIG. 2—SECTION OF CUTTER MADE BY THE DAVIDSON PROCESS, ETCHED IN 5 PER CENT NITAL SOLUTION FOR 30 SECONDS. X 100

FIG. 3—SECTION OF MILLING CUTTER TOOTH MADE BY THE DAVIDSON PROCESS, ETCHED IN 5 PER CENT NITAL SOLUTION FOR 7 MINUTES. X 400

shape and some progress has been made in this art. It is understood that one large manufacturer has such a process in more or less regular commercial use. There are three difficulties with this process, from the point of view of ordinary steel melting practice: First, that of getting the steel killed so dead that it will be free of blow-holes as cast; second, that of producing a metal fluid enough to flow into the fine parts of the mold and give sharp true castings. If this cannot be done, only the rough cuts in machining the cutters are saved and the difficulty involved in cutting the scale may easily offset this gain. Third, that of producing a satisfactory structure to give great endurance and long life to the steel without the refining of the grain which is often considered to come only from the forging operation.

How Early Tests Were Made

A year or two ago some tools made by a direct casting process came into the hands of A. C. Davidson. It was soon ascertained that, for the reasons just stated, they could not compete with the older type of tools either in quality or price. Mr. Davidson had previously found that it was possible to kill steel much more completely than had hitherto been possible. He had also had a wide experience in the production of steels for different purposes and in their heat treatment. He believed that by the application of his process of killing the steel and his knowledge of heat treatment he could eliminate the defects in cast tools. He therefore began a long series of experiments for that purpose.

In April, 1918, the writer was retained to supervise a test of the process and see whether the claims made for it could be substantiated. Mr. Davidson had at that time no works of his own and it was necessary to hire a crucible furnace, which had at one time been used for making crucible castings but which had been out of use for some months. This furnace was of poor design and in a bad state of repair, but it was thought that it would serve for a demonstration heat. Ten 100-pound crucibles were accordingly charged under the inspection of the writer and put into the furnace. One of these was charged entirely with high-speed steel scrap, largely that resulting from previous melts made by Mr. Davidson. This was done with the object of proving whether or not the gates and risers resulting from the casting operation could be worked up in subsequent heats, since the losses that would result would destroy the value of the process if these had to be thrown away.

The furnace worked so badly that the heat instead of coming out in six

FIG. 4—SECTION OF CAST HIGH-SPEED STEEL, ETCHED IN 4 PER CENT NITAL SOLUTION FOR 30 SECONDS. X 100

hours, as it should, was in the furnace about nine to ten hours and only three pots became hot enough to pour at all, the metal even from these being entirely too dull for the best results. After this number had been poured, the cover over the furnace flue collapsed and the heat had to be terminated. The conditions surrounding the test were therefore in every way unfavorable and disadvantageous. Nevertheless, a number of milling cutters, countersinks for ship rivets, and forming tools were cast, some of the best of them coming from the pot charged entirely with scrap. Two of the cutters and one of the countersinks were taken from the works by the writer, etched with private identification marks, turned back to Mr. Davidson for annealing, machining, hardening and grinding and were then returned by him to the writer for test. In order to have a fair standard of comparison, a well-known side milling cutter of one of the best brands of high-speed steel was bought directly from the works. The 6 x ¾-inch milling cutter contained a number of steam holes caused by wet molds. It was by no means a perfect casting, nevertheless it stood up favorably under the most extreme test that could be given it with the cutter.

A 2½ x 2½-inch side milling cutter was then put in the machine and tested at gradually increasing speeds until finally the limit of the machine was reached. The cutter was taking a depth cut like a keyseat in a bar of steel of 0.30 or 0.40 per cent carbon, this cut being the width of the cutter by ¼-inch deep. On the final test, the cutter was run at a speed of 400 revolutions per minute, with a feed of 7 inches per minute. This is a linear speed of about 250 feet per minute and, as stated, was the limit of the machine. The cut was run as far as the clamps on the test bar would permit, and as it was not possible to test the cutter any more severely, the test was stopped and the cutter taken out. It showed no sign of the gruelling test it had been through.

Features of "Killing" Process

In regard to the process of killing, which not only eliminates the blow-holes completely but seems to give the steel a fluidity far beyond that of ordinary high-speed steel, the writer is unable to speak. The material used for killing is a secret of which the writer has no knowledge whatever. It may be said, however, that the results are striking. The notable features are three: First, the extraordinary freedom from blow-holes; second, the fluidity of the metal; and third, the entire absence of coarse crystallization in the casting.

In regard to the first of these features, it may be stated that the foundry ran for several weeks before

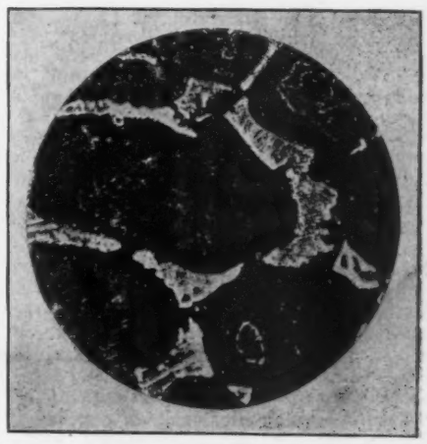


FIG. 5—SECTION OF CAST HIGH-SPEED STEEL, ETCHED IN 5 PER CENT NITAL SOLUTION FOR 30 SECONDS. X 100

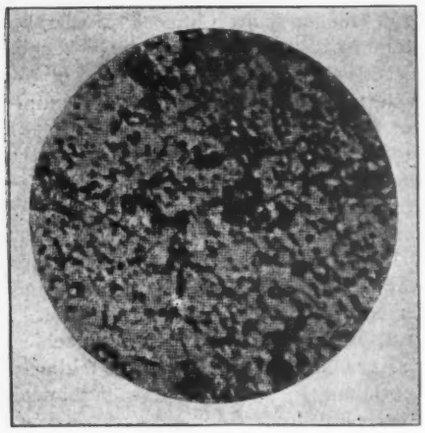


FIG. 6 — SECTION OF A MILLING CUTTER, ETCHED IN 5 PER CENT NITAL SOLUTION FOR 7 MINUTES. X 100

the completion of its baking oven, pouring the steel largely into green-sand molds, and yet made satisfactory tools, there being only a few steam holes near the surface. Since the drying oven was put into operation, blow-holes of any description are practically unknown. In regard to the second, the metal, instead of having a comparatively ropey pour, is thin and fluid more like good hot cast iron than like steel. As a result the details of small cutters are cast practically perfect. In regard to the third feature, it is well known that most steel, when cast, has a coarsely crystalline or fiery structure, but an examination of the fresh fractures of this steel shows that this is almost wholly absent; in fact, the structure of this steel, as cast, looks more like that of forged steel than it does like a casting.

Photomicrographs, which were prepared by Sauveur & Boylston, Cambridge, Mass., reveal the microstructure of a first-class make of forged and machined high-speed steel, of a cutter made of an ordinary cast high-speed steel, and of a tool made by the Davidson process. With these are submitted a statement by H. M. Boylston, which is as follows:

"This was a piece about ¾-inch in section, showing a scale on all sides but one, which had evidently been cut. We prepared the cut surface and photomicrographs, Figs. 1 and 2, represent the structure respectively at 100 and 400 diameters. It will be seen that the structure is fairly fine for a casting and consists of a light matrix in which some polyhedral networks can be distinctly seen, Fig. 2. Embedded in this matrix are three other constituents; one a dark mottled constituent resembling troosto-sorbite in ordinary carbon steel and resembling also the dark constituent in a cast high-speed steel of ordinary composition or of an ordinary high-speed steel after forging and annealing. The second constituent is a light hard one forming a herring-bone design and is plainly a eutectic of some sort. It is similar in quality but greater in quantity to the so-called carbide envelopes found in ordinary cast high-speed steel. The fourth constituent consists of a series of separate small rounded hard white spots similar to the excess carbide found in an ordinary high-speed steel both before and after hardening, provided the sum of the carbon, tungsten and chromium contents are high enough. The structure of this sample is more like that of an ordinary high-speed steel casting than that of a well-treated high-speed steel after forging, annealing, and heat treatment, but it is also clearly different from the structure of an ordinary high-speed steel casting of good quality, in that the dark constituent of a sorbitic appearance is much less in quantity than in an ordinary high-speed steel casting, while the herring-bone eutectic is larger in quantity than is found in the carbide envelopes of an ordinary high-speed steel casting. The ordinary casting, also, does not contain the separate bright white constituents while the tool made by the Davidson process apparently has some austenite (the polyhedral grains dimly seen in places in Fig. 2).

"Photomicrographs of an ordinary commercial high-speed steel casting (from an ingot) magnified 100 and 400

FIG. 7 — SECTION OF A MILLING CUTTER, ETCHED IN 5 PER CENT NITAL SOLUTION FOR 7 MINUTES. X 400

diameters respectively are shown for comparison in Figs. 4 and 5.

"The structure of the commercial milling cutter submitted to us is that of a commercial high-speed steel with an unusually large amount of free carbide forming almost complete envelopes in some cases. The background is austenite with some fine markings, which we judge to be due to the tempering process. The structure as a whole is different from the cutter made by the Davidson process but is characteristic of an ordinary high-speed steel forged cutter that has been heat treated and tempered. There is a dark constituent surrounding the free carbide areas in this sample, which would seem to indicate that the heating for hardening has either been too low or has been continued for too short a time, so that the annealed structure is not entirely obliterated. The fact that the networks of austenite are often incomplete and the large amount of free carbide present are additional evidence of this defective heat treatment. While we have called this defective heat treatment, it may not be a serious matter in a cutter of this size, although we should look for brittleness at the edges of the cutting teeth which are on the periphery."

Judging from the number of cases in which the cast tools have oustripped all others in such tests, a suggestion not unworthy of consideration is that the structure shown by the tools made by the Davidson process is that at which other toolmakers should aim.

Cast Iron Output Declines

In 1917 the production of cast iron pipe declined considerably and when statistics are available for the output last year, it will be shown that war activities greatly reduced the manufacture of this class of castings. Also, the restrictions placed on public work of all kinds during the war had a marked effect on reducing output. In 1917 the total production of gas, water and soil pipe was 999,101 tons, as compared with 1,214,333 tons in 1916. The production of gas and water pipe, which includes culvert pipe, was 696,097 tons in 1917, as against 874,129 tons in 1916. The production of fittings declined from 60,497 tons in 1916 to 52,076 tons in 1917. The total in 1917 was 748,173 tons as compared with 934,626 tons the previous year. Soil pipe reached a total of 175,625 tons in 1917, as against 206,494 tons in 1916, and plumbers' fittings aggregated 75,303 tons in 1917, showing an increase over 1916 when 73,213 tons were made. The total soil pipe and plumbers' fittings produced in 1917 was 250,928 tons, against 279,707 tons in 1916.

Organize New Engineering Firm

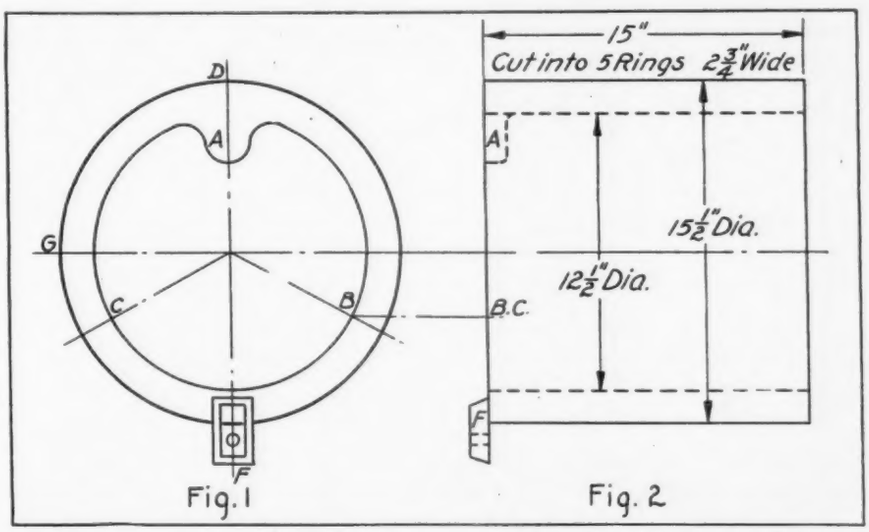
The engineering firm of the Withington-Roberts-Wright Co., with offices at 622 Swetland building, Cleveland, has been organized and the following officers have been elected: President, P. H. Withington; vice president, A. B. Roberts, and treasurer, G. O. Wright. Branch offices have been established at 924 Broad street, Boston; 112 East Nineteenth street, New York; 1320 Munsey building, Baltimore, and 1514 Harris Trust building, Chicago.

The American Metal Products Co., Milwaukee, manufacturer of aluminum bronze bearing metal and acid-resisting bronze, has appointed the following district sales managers: Pittsburgh, J. S. Morrison, Oliver building; Cleveland, Fred J. Michels; Chicago, G. B. Perlstein; Detroit, Charles Kenyon, Penobscot building; and New York, J. Jronman, 29 Broadway.

Finding the One Best Way in the Pattern Shop

Importance of Clamping Lugs on Castings—How the Apprentice Made the Pinion Pattern—How Patterns Should be Made

WHILE walking through the machine shop of our plant recently my attention was directed to a casting which one of the machinists was struggling with in his effort to fasten it to the face plate of the lathe. The casting was a cylinder and was to be finished to the dimensions given in the accompanying sketches. The pattern for this cylinder was not unusual and should not have caused the patternmaker any trouble in its construction; nevertheless, a mistake was made. In the construction of this pattern three errors were traced that involved difficulties in the machining of the casting. This pattern was made with three clamping lugs. This was wrong because lathe face plates and boring mill lathes are made with holes and T-slots on the quarter and, occasionally, when the casting is to be fastened with bolts on the face plate of the lathe or on the table of the boring mill, it is seldom that the holes in the casting lugs can be located to match the holes in the machine. The three lugs were placed on the inside of the pattern as shown at *ABC*, Fig. 1. Their location was inconvenient to say the least as it was almost impossible for the machinist to get at the clamping bolts when fastening the casting on the face plate or the boring mill table. The patternmaker put the clamping lugs on the inside and flush with the end face of the pattern as shown in Fig. 2. His reason for making it in this way was that the pattern could be placed flat on a board and molded with the whole of the pattern being in the drag half of the flask.



SKETCH OF A CYLINDER PATTERN SHOWING HOW CLAMPING LUGS SHOULD BE LOCATED

This method of procedure was found to be good, but note what happened. The draftsman in making his calculations figured that five rings could be cut from this cylinder casting with a comparatively small waste of stock. However, the patternmaker defeated the designer's intentions by placing the clamping lugs on the inside and in the path of the boring tool. Therefore, to secure five finished rings out of each cylinder casting, it was necessary to rechuck the fifth ring and bore the clamping lugs away. The proper method for locating these clamping lugs is shown at *F*, Figs. 1 and 2, and these should have been located on the quarter as indicated by *D F* and *G*. This is good patternmaking and meets the requirements of the machine shop.

Recently, a patternmaker who had little experience in foundry or machine shop practice brought a cylinder or ring pattern to the foundry. It was 18 inches outside diameter, 16 inches inside and 11 inches deep. It was provided with four clamping lugs, ½-inch thick, 2 inches wide and these projected 3¼ inches beyond the pattern. The foreman molder asked the patternmaker what the projections were for. The patternmaker informed him that these were clamping lugs to enable the machinist to clamp the casting to the face lathe. The foreman molder thereupon informed the patternmaker that there would be no lugs on the casting when the machinist started to do the clamping as the lugs would be broken off in shipment. What the molder predicted came to pass.

Four clamping lugs on a casting, as shown at *F*, Figs. 1 and 2, unless otherwise instructed, may be defined as pattern-machine-shop mechanics.

M. E. DUGGAN

How the Apprentice Made the Pinion Pattern

By William Ballantine

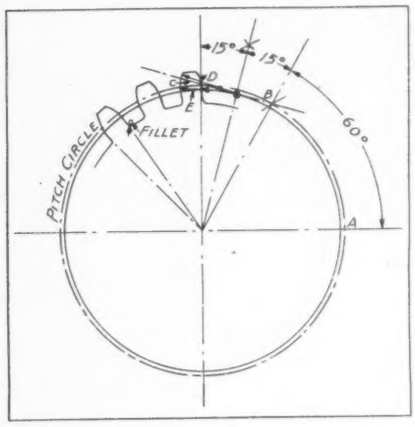
JIM, the apprentice, always wanted to make a gear pattern. At last an involute pinion arrived that the boss thought would be a good one to start with and the following conversation ensued:

"Well, Jim, do you think you can make a pattern of this pinion?" Jim looked up a little surprised. He hesitated a moment, then his face brightened up and he said: "Sure I can, if you show me how to lay it out." "Alright then, the first thing you do will be to glue up a solid block, large enough to cut the teeth out of the solid and then I will show you a short and easy method to lay out the gear teeth accurately."

In a few minutes Jim had glued up the block for the pinion and was anxious to start.

"Well, Jim, how many teeth and what is the pitch? You're right, 20 teeth and one-inch pitch. Now the first thing will be to find the pitch diameter by multiplying the pitch by the number of teeth and divide by 3.1416, which will be the diameter of the pitch circle. Thus: $20 \times 1 \div 3.1416 = 6.36 +$. We will

now draw a sketch from which you can make the layout. The first thing is to draw vertical and horizontal center lines, then draw the pitch circle and then place the point of the dividers on the horizontal line where it intersects



SCRIBING THE TEETH FOR AN INVOLUTE PINION

the pitch circle at the right. Let us call that point *A* and inscribe an arc intersecting the pitch circle above the center line which will be 60 degrees. We will call that point *B*, and where the pitch circle intersects the vertical center line, we will call the point *C*. We will now draw a straight line, or chord, connecting *B* and *C*. Then we will bisect *B* and *C* which will give us 15 degrees.

"The next thing is the height and thickness of the tooth. Well, this little rule will apply to all cast gears laid out by this method, and gives a good strong, well-shaped tooth. The height of the tooth is 0.7 of pitch, 0.3 outside and 0.4 inside the pitch circle. The thickness of the tooth at the pitch circle will be 0.46 of the pitch and the space, 0.54, thus allowing proper clearance for cast gears.

Dividing the Pitch Circle

"The next step will be to divide the pitch circle into the number of equal parts corresponding to the number of teeth—in this case 20—starting at the vertical center line at point *C*, and moving toward the left you mark the thickness of each tooth. On the pitch circle we will mark off the distance of 0.3 of the pitch outside the pitch circle which is the point of the teeth, and the distance of 0.4 inside the pitch circle which is the root of the teeth. The next move will be to draw a circle that just touches the cord *B* and *C*, which will be used in drawing the different radii of the tooth.

"Having the height and thickness of the teeth, the next will be to shape them. You should remember that involute teeth always are radial flanks until you have over 34 teeth and above that number you have but a single curve for the side of the teeth and that is why you sometimes hear them called single curved teeth.

"This pinion having less than 34 teeth, the flanks are radial. We will now set our dividers, using the point where the 15-degree line bisects the chord *B-C* as a center and setting the dividers to the opposite side of the tooth placed at the left of the vertical center line, you draw the point of the tooth to the pitch circle, which we will call radius *D*. To prevent a sharp break where the flank of the tooth joins the point, we will draw a second radius between the pitch circle and the circle used to lay out the teeth; this radius we will call *E* and is found by multiplying the pitch by the number of teeth by 0.30-inch. Thus 1 x 20 x 0.03 inch equal 0.6 inch, the length of radius *E*. The flank of the tooth is radial and all that is left is the fillet at the root of the tooth which will be 0.1 of the pitch which gives a strong, well-shaped tooth.

"This method applies to any size or pitch gear and the following simple rules are to be remembered:

Pitch diameter = Number of teeth x pitch ÷ 3.1416.

Height of tooth = 0.7 of pitch, 0.3 outside pitch circle, 0.4 inside pitch circle.

Thickness of tooth = 0.46 of pitch.

Space = 0.54 of pitch.

Flank radius = 0.03 x number of teeth x pitch.

Fillet = 0.1 of pitch.

"This completes the layout of the pinion and all that is left is to turn up your block, thoroughly shellac the end grain of the wood, lay out the teeth on the block, saw it out on a band saw, sandpaper, shellac and the job is complete.

"This method requires no odontograph or any chart, just a little memory."

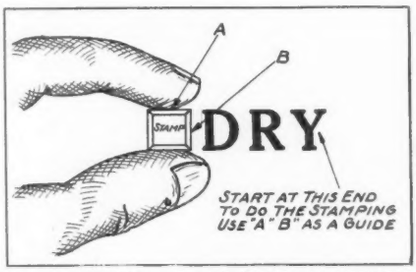


FIG. 1—METHOD OF STAMPING A PATTERN, STARTING AT THE END OF THE WORD

How Patterns Should be Marked

By M. E. Duggan

The artistic appearance of a well-constructed and well-finished pattern often is marred by the careless marking or stamping of the number or name on the model. Neat and correct marking adds to the finished appearance of the pattern and prevents mistakes in the foundry. Each pattern and pattern part should be stamped so that it can be readily located and assembled. Some manufacturers mark their patterns with steel stamps and also use raised letters or plates. The double marking is desirable because if the raised letters are knocked off the patterns can still be identified by the figures or letters stamped in the wood. Also, by transferring to the castings the raised letters and figures, the cast part is readily identified in the foundry, shipping room, machine shop, etc.

When a pattern is to be marked with a steel stamp it is the prevailing practice among patternmakers to start at the beginning of the word, whereas the stamping can be done more accurately by starting at the end, as indicated in Fig. 1. Metal name plates should be attached to the pattern lengthwise with the grain of the wood, as shown at *A*, Fig. 2, and never across the grain as at *B*. The contraction of the pattern when the name plate is attached across the grain frequently will cause the plate to bulge in the center. Therefore, when the pattern is taken to the foundry

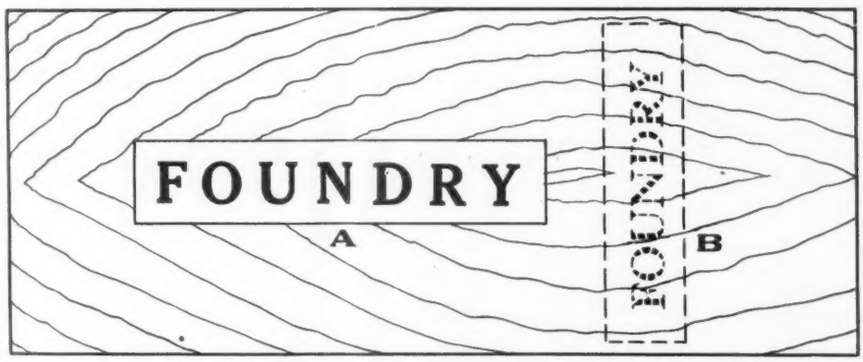


FIG. 2—RIGHT AND WRONG WAY OF ATTACHING NAME PLATE TO A PATTERN

in this condition, the molder frequently is tempted to pull off the plate and the model thereby loses its identification mark before it is used once.

EPICYCLOIDAL GEAR TEETH

By Walter M. Hippler

A=0.3 x pitch=distance between the pitch and addendum circles.

B=0.375 x pitch=distance between pitch and root circles.

C=0.466 x pitch=thickness of gear tooth.

D=distance from pitch circle to line of flank centers.

E=distance from pitch circle to radius base line.

F=face radius of gear tooth.

G=flank radius of gear tooth.

Table I

Values for Layout of 12-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	..	1/64	1/16	..
¾	7/32	9/32	11/32	..	1/64	3/64	..
1	5/16	3/8	15/32	..	1/32	1/64	..
1⅛	11/32	27/64	17/32	..	3/32	3/32	..
1¼	3/8	15/32	27/64	..	1/32	1/16	..
1⅜	13/32	33/64	21/32	..	3/32	7/64	..
1½	7/16	9/16	11/16	..	1/32	3/32	..
1⅝	½	5/8	¾	..	3/32	1/64	..
1¾	17/32	21/32	13/16	..	3/32	1⅛	..
1⅞	9/16	45/64	⅞	..	3/32	1/16	..
2	19/32	¾	15/16	..	1/64	1/32	..
2¼	43/64	33/32	1 1/64	..	1/64	1/16	..
2½	¾	15/16	1 1/32	..	1/64	1/32	..
2¾	53/64	1 1/32	1 3/32	..	1/64	1¼	..
3	27/32	1⅛	1 3/16	..	1/16	1/64	..
3¼	29/32	1 7/32	1 13/64	..	1/16	2/32	..
3½	1 1/64	1 5/16	1⅜	..	1/16	2¼	..
4	1 11/64	1½	1 9/64	..	1/64	2 1/16	..

Table II

Values for Layout of 13-14-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	13/64	1½	1/64	3/8	2 13/32
¾	7/32	9/32	11/32	2¼	1/64	½	3 5/16
1	5/16	3/8	13/32	3	3/32	3/32	4 13/32
1⅛	11/32	27/64	17/32	3 3/8	3/32	¾	5 13/32
1¼	3/8	15/32	27/64	3¾	3/32	1/8	6
1⅜	13/32	33/64	21/32	4⅛	3/32	3/32	6 5/16
1½	7/16	9/16	11/16	4½	3/32	3/32	7 13/64
1⅝	½	5/8	¾	4⅞	3/32	1 1/16	7 5/16
1¾	17/32	21/32	13/16	5¼	3/32	1 1/64	8 13/32
1⅞	9/16	45/64	⅞	5 5/8	1/64	1 1/32	9
2	19/32	¾	15/16	6	1/64	1 1/16	9 5/16
2¼	4 3/64	37/32	1 3/64	6¾	1/64	1 3/32	10 15/16
2½	¾	15/16	1 5/32	7½	1/64	1 5/16	12
2¾	53/64	1 1/32	1 5/32	8¼	1/64	1 3/32	13 3/32
3	29/32	1⅛	1 13/32	9	1/16	1 1/64	14 13/32
3¼	31/32	1 7/32	1 13/64	9¾	1/16	2⅛	15 5/8
3½	1 1/64	1 5/16	1 5/8	10½	1/16	2 3/32	16 13/32
4	1 11/64	1½	1 9/64	12	1/64	2 1/16	19 5/16

*In this chart for 12 teeth only, the dimensions D and G are omitted as the flanks may be formed with sufficient accuracy from the radii given for the face.

(*Continued on Data Sheet No.* 280)

EPICYCLOIDAL GEAR TEETH

By Walter M. Hippler

(*Continued from Data Sheet No.* 279)

Table III

Values for Layout of 15-16-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	1/16	1/64	1/32	1¼
¾	5/32	5/32	11/32	3/32	½	1 7/8	
1	5/16	3/8	15/32	1 3/32	3/32	3/32	2½
1⅛	11/32	27/64	17/32	1 5/16	3/32	¾	2 13/16
1¼	3/8	15/32	27/64	1 3/8	3/32	3/32	3⅛
1⅜	13/32	33/64	21/32	1 13/32	1/64	⅞	3 7/16
1½	7/16	9/16	11/16	1 1/2	1/64	1	3¾
1⅝	½	5/8	¾	1 5/32	1/64	1 3/32	4 1/16
1¾	17/32	21/32	13/16	1 5/16	1/16	1 1/64	4 3/8
1⅞	9/16	45/64	⅞	2 1/16	1/16	1¼	4 13/16
2	19/32	¾	15/16	2 3/8	1/16	1 1/32	5
2¼	43/64	27/32	1 3/64	2 13/32	1/16	1½	5 5/8
2½	¾	15/16	1 5/32	2¾	1/64	1 3/32	6¼
2¾	53/64	1 1/32	1 5/32	3 1/32	1/64	1 7/32	6⅞
3	29/32	1⅛	1 13/32	3 5/16	3/32	2 1/64	7½
3¼	31/32	1 7/32	1 13/64	3 5/8	1/64	2 1/16	8⅛
3½	1 1/64	1 5/16	1 5/8	3 7/8	1/64	2 3/32	8¾
4	1 11/64	1½	1 9/64	4 13/32	1/8	2 1/16	10

Table IV

Values for Layout of 17-18-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	3/32	1/64	1/32	3/32
¾	5/32	5/32	11/32	1/16	1/32	3/32	1 15/32
1	5/16	3/8	15/32	1/8	1/64	1/16	1 13/32
1⅛	11/32	27/64	17/32	3/16	1/64	1/32	2 5/16
1¼	3/8	15/32	27/64	7/16	1/64	3/32	2 7/16
1⅜	13/32	33/64	21/32	1/4	1/64	1/16	2 11/16
1½	7/16	9/16	11/16	1 1/16	1/16	1 3/32	2 15/16
1⅝	½	5/8	¾	1 1/8	1/16	1 3/64	3 3/64
1¾	17/32	21/32	13/16	1 3/32	1/64	1⅛	3 7/16
1⅞	9/16	45/64	⅞	1 5/16	1/64	1¼	3 13/32
2	19/32	¾	15/16	1 13/32	1/64	1 3/32	3 13/32
2¼	43/64	27/32	1 3/64	1 13/32	1/32	1 3/32	4 1/16
2½	¾	15/16	1 5/32	1 13/32	1/32	1 3/32	4 7/16
2¾	53/64	1 1/32	1 5/32	1 13/32	1/32	1 7/32	5 3/16
3	29/32	1⅛	1 13/32	2 7/16	1/16	2 1/64	5 13/32
3¼	31/32	1 7/32	1 13/64	2 13/32	1/16	2 1/16	6 11/32
3½	1 1/64	1 5/16	1 5/8	2 7/16	1/16	2 3/32	6 13/32
4	1 11/64	1½	1 9/64	2 13/16	1/32	2 1/16	7 13/32

Table V

Values for Layout of 19-21-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	1/4	1/64	3/32	1/8
¾	5/32	5/32	11/32	3/16	1/32	1 7/32	
1	5/16	3/8	15/32	½	1/64	1/32	1 5/16
1⅛	11/32	27/64	17/32	5/16	1/64	3/32	1 13/32
1¼	3/8	15/32	27/64	5/8	1/64	⅞	2 3/32
1⅜	13/32	33/64	21/32	11/16	1/64	3/32	2¼
1½	7/16	9/16	11/16	¾	1/16	1 1/16	2 7/16
1⅝	½	5/8	¾	13/16	1/16	1 5/64	2 13/16
1¾	17/32	21/32	13/16	⅞	1/64	1 3/32	2 13/16
1⅞	9/16	45/64	⅞	15/16	1/64	1 7/64	3 3/16
2	19/32	¾	15/16	1	1/64	1 1/32	3 7/16
2¼	43/64	27/32	1 3/64	1 1/8	1/32	1 3/32	3 13/16
2½	¾	15/16	1 5/32	1 1/4	1/64	1 1/4	4 1/16
2¾	53/64	1 1/32	1 5/32	1 3/8	1/64	1 5/32	4 3/16
3	29/32	1⅛	1 13/32	1½	1/8	2 1/64	4 13/16
3¼	31/32	1 7/32	1 13/64	1 5/8	1/8	2 3/32	5 1/16
3½	1 1/64	1 5/16	1 5/8	1¾	1/64	2 1/32	5 5/16
4	1 11/64	1½	1 9/64	2	3/32	2 1/16	6 1/32

Table VI

Values for Layout of 22-24-Tooth Gear

Pitch	A	B	C	D	E	F	G
½	5/32	3/16	15/64	3/16	3/32	3/64	3/32
¾	5/32	5/32	11/32	1 7/32	3/32	3/32	1 5/16
1	5/16	3/8	15/32	3/8	1/64	3/32	1 7/16
1⅛	11/32	27/64	17/32	7/16	1/64	1/16	1 13/16
1¼	3/8	15/32	27/64	1/2	1/64	3/32	1 15/16
1⅜	13/32	33/64	21/32	9/16	1/64	3/32	2 1/16
1½	7/16	9/16	11/16	5/8	1/64	1 1/64	2 3/16
1⅝	½	5/8	¾	11/16	1/64	1 1/64	2 5/16
1¾	17/32	21/32	13/16	3/4	1/64	1 3/64	2 7/16
1⅞	9/16	45/64	⅞	13/16	1/64	1 3/64	2 9/16
2	19/32	¾	15/16	7/8	1/64	1 1/32	2 11/16
2¼	43/64	27/32	1 3/64	1	1/64	1 1/32	2 13/16
2½	¾	15/16	1 5/32	1 1/8	1/64	1 3/32	2 15/16
2¾	53/64	1 1/32	1 5/32	1 1/4	1/64	1 5/32	3 1/16
3	29/32	1⅛	1 13/32	1 3/8	1/64	1 7/32	3 3/16
3¼	31/32	1 7/32	1 13/64	1 7/16	1/64	1 9/32	3 5/16
3½	1 1/64	1 5/16	1 5/8	1 1/2	1/64	1 5/16	3 7/16
4	1 11/64	1½	1 9/64	1 5/8	1/64	1 3/8	3 9/16

(*Continued on Data Sheet No.* 281)

THE FOUNDRY DATA SHEET, APRIL 1, 1919

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

Note—This sheet may cut into two sections, 5 x 7 inches, and may be readily bound in note book form.

Pointers for the Plater When Buying Equipment--II

Suitable Sand-Blast Installations Play an Important Part—Applying Finishes Successfully and Fixing Them by Baking Require Proper Apparatus

By E P Later

IN a preceding article several of the more important pieces of apparatus used in the plating room were discussed in detail, for the purpose of pointing out the salient points which the prospective purchaser of such equipment should bear in mind. The machinery employed in the preparation of parts for finishing and for the application of japans and similar coatings requires further consideration.

The usual operations preliminary to finishing are removal of rust and scale, grinding, polishing and buffing. The machines used for these purposes, however, are so simple and familiar to everyone that their selection presents no difficulty. For the removal of sand and scale and the production of a matt surface admirably adapted to subsequent plating, in cases where a buffed finish is not required, or to the application of paint, japan or enamel, the sand-blast is finding wide favor, largely because it does the work quickly and cheaply. Sand-blasting usually leaves the surface of the parts in much better condition than acid-pickling.

Selecting the Sand-Blast

As is well known that the sand-blast applies the cutting or abrasive action developed when a hard and finely divided substance such as sand or flint is discharged at high speed against the surface to be cleaned. In the actual application of this principle a number of different machines have been designed to handle the different classes of work. The purchaser of such equipment is confronted with the problem of selecting the type and size which will give the best results for the least money, both in first cost and in operation. A brief description of the various machines will make it easier to attack this problem.

Air is ordinarily employed to drive the abrasive against the parts to be finished and there are several methods of applying this air pressure. In the direct pressure type machine the air and sand are kept at any desired pressure in a suitable container and discharged together through a nozzle, thereby obtaining the highest possible velocity. The ordinary hose sand-blast belongs to this type.

In the suction or syphon system the abrasive is carried to the nozzle by the suction created by compressed air which discharges through it and projects the abrasive against the work. The so-called sand-blast gun operates in this way.

In the gravity system the abrasive is brought to a point just above the nozzle and then makes its way by gravity to the nozzle. In machines of this type the air and abrasive are mixed just before being discharged from the nozzle. Automatic or self-contained sand-blasting machines are of the suction or gravity type.

There are three general classes of sand-blast machines in ordinary use. Mention was made of the sand-blast hose outfit, which is simply an iron tank, containing the air and sand, provided with a rubber hose to the other end of which is attached a suitable nozzle. This is not only the earliest type of machine, but the most flexible and generally useful. The long hose, which may be any length up to 50 feet or more depending on the diameter of the nozzle and the air pressure, gives a wide radius of action. The ease with which the blast can be directed upon any desired spot makes an outfit of this sort extremely useful, particularly when a variety of miscellaneous work is to be handled, inasmuch as parts of any size can be treated with equal ease and effectiveness.

In the process of sand-blasting, a large amount of dust is produced from the breaking-up of the sand, or other abrasive, into extremely small particles and from the sand, scale, rust, etc., present on the work. This dust is not only bad for the health, but it is objectionable to the plater or japanner. For this reason, unless the sand-blasting can be done out-of-doors or in a place where the dust produced can do no harm, some provision should be made for removing it. Therefore, sand-blast rooms usually are installed in plants where any large amount of this work is done.

Preventing the Dust Nuisance

Practically, these rooms are merely enclosed chambers of sufficient size to contain the apparatus and work to be cleaned. They may be built of wood, brick or steel; in the latter cases it is advisable to line them with wood, at least the portion of the walls exposed to the sand-blast, since otherwise the walls will be rapidly worn away. Preferably, the floor should be grated, with a hopper beneath to catch the sand. The debris then can be taken by a conveyor or an exhaust system to a separator where the usable sand is screened out and returned to the sand bin, all coarse material being rejected. The dust in the air exhausted from the room can be filtered out by the use of screens or centrifugal arresters. The former consist of wooden frames covered with a certain grade of cotton duck and are to be used in cases where all of the dust must be removed from the air before it is discharged either into the atmosphere or back into the sand-blast room.

The centrifugal arrester removes a large part of the dust, enough in many cases to permit the air to be discharged into the atmosphere without further treatment.

Cabinet Type Sand-Blasts

The sand-blast cabinet is a widely used type of outfit. It comprises a small, closed chamber provided with a stationary nozzle; a hole in one side, closed with a curtain, permits the introduction of the work, which is held in the hands and turned and manipulated until all of the surfaces have been acted upon to the desired extent. A glass window in the top enables the operator to watch the work, while it is being treated. An exhaust system removes the sand and dust. The dust is finally filtered out of the air and the usable sand is returned to the bin.

There is another and similar type of cabinet machine, differing principally in the fact that the nozzle is attached to a flexible hose; the blast can thus be directed wherever desired.

In response to a demand for sand-blasting machines which can be operated with less labor, considerable progress has been made in the past few years in the design of automatic equipment, of which the revolving table sand-blast is one example. The designs vary somewhat, but the basic idea embodies a table or platform which moves and thus carries the parts laid on it, past a series of fixed

nozzles arranged to give as even a distribution of the blast as possible.

The table is supported by a vertical shaft which runs in dust-proof bearings; its surface is composed of steel bars which can be replaced easily when they become too much worn by the blast. Friction drive usually is employed to turn the table for the reason that with a stronger or more positive drive either the machine or some of the parts under treatment would certainly be broken in case they became caught somewhere.

A housing covers all but one side of the table, to allow the work to be put on and taken off and curtains of rubber or other material are placed at the entrance to the blasting chamber, to prevent the escape of sand and dust into the room. The spent sand and refuse from the work are collected in a hopper and taken to a separator where the coarse material is automatically screened out and rejected and the usable sand returned to the bin. The fine dust is removed by an exhaust and, if necessary, filtered out of the air by a dust arrester.

The sand-blast tumbling barrel affords a means of treating, with a minimum of labor, any parts whose size or character are such that they can be tumbled at a low rate of speed. These barrels are made in both horizontal and tilted models and a number of types are on the market. These exhibit more or less diversity of construction, but all are designed to turn the parts over-and-over and thus expose all surfaces to the action of the sand-blast issuing from a number of nozzles.

In at least one type of sand-blast tumbling barrel the sand which has been discharged from the nozzles is collected, as the barrel revolves, in small hoppers or pockets and returned to a container to be used again. The exhaust connected to the barrel thus removes only the fine dust. Usually, however, both the used sand and dust are removed by the exhaust, the good sand being then returned to the bin to be used over again while the dust is collected by arresters.

Selecting Equipment

The selection of the type and size of sand-blast machine best suited to the conditions which obtain involves the consideration of a number of factors, of which only a few can be mentioned here. It can be said, however, that the kind and character of the metal parts which it is desired to treat together with their average size or weight, shape and daily tonnage are the most important items.

Of course, no one machine can handle all classes of work to equal advantage and as a general rule it will be found that for all around use, where a variety of work, both large and reasonably small is to be handled, the hose type machine is satisfactory. When there is a large quantity of small work adapted in size and shape to cleaning in the sand-blast barrel, there is little question but that this type of equipment is the most economical. Parts which are too large, or otherwise unsuited for the latter treatment, provided they are not of too complicated design, can be handled with the least labor on the revolving table machine. In cases where a comparatively small volume of miscellaneous work, or work which is of intricate design must be handled, the cabinet type of sand blast will usually be found to meet the requirements successfully.

Much depends on the proper care and management of sand-blast machines. As might be expected, the selection of the abrasive is a matter of some importance. Sand was the first abrasive used and there is no denying that it meets a range of requirements. Sand should, however, be sharp and clean and contain only a small amount of clay. When an excess of clay is present, undue quantities of dust are produced. Furthermore, it is advisable to screen the sand each time before using, in order to remove the material which is too fine to do effective work.

Protection From Moisture

If the air pipe lines are long they should be protected in some way from condensation. Any moisture or water appearing in the air as it enters the machine should be removed by a trap or other suitable device. It is important that only dry sand be fed to the machines as wet or damp sand will cake and clog up the system and may be the source of much trouble. Moisture may be removed from the abrasive by spreading it out on a heated table or pan, but it is well to avoid heating sand too hot as this tends to disintegrate it; it should be allowed to cool down to somewhere near room temperature before it is put into the machine.

In the past few years metal abrasives, diamond grit, chilled shot and other materials have replaced ordinary sand in many establishments. As a rule these clean faster than sand, the life of these abrasives is many times that of sand, and also, less dust is produced. On the other hand, it is claimed that metal abrasives are unsuited for certain classes of work; in electro-galvanizing, for instance, trouble has been experienced from the metallic dust which adheres to the parts and thus prevents an even deposit from being obtained.

Because of the many improvements which have been made in recent years in the manufacture and method of application of that class of finishing materials known broadly as japans and enamels the use of these has increased rapidly. These materials afford a means for producing on metal parts a finish which, when properly applied, leaves little to be desired either in the matter of appearance or protection. Like other finishing processes, however, the production of such a finish requires suitable apparatus and considerable attention to detail, to obtain the best results.

Japans and enamels are applied by dipping, brushing or spraying, depending on the nature of the work and the quality of finish desired. Inasmuch as the equipment employed in dipping and brushing is so simple as not to require special mention, only the spraying apparatus will be considered.

A sprayer is an adaptation of the familiar atomizer and in its essentials comprises a container of some sort, to hold the japan or other liquid, provided with a nozzle. Two tubes lead from this, one dipping down into the japan and the other being connected to a source of compressed air. Under the influence of the suction occasioned by the rush of compressed air the japan is drawn up into the nozzle, where it is instantly vaporized and projected out in the form of a fine spray. Sprayers, of course, are provided with a means of adjusting the nozzle, to give as light or heavy a spray as desired.

In another type of outfit the japan is kept in a large, separate container under air pressure, which thus serves to force it through a hose connected to the sprayer. This type has the advantage over the others in that no time is lost by the operator in stopping to fill the container. In general, when selecting sprayers ruggedness, simplicity of construction and ease of regulation are points which should be borne in mind.

Ventilation is Important

It is hardly necessary to mention that the rooms wherein japanning, painting or lacquering are done by dipping or brushing require adequate ventilation. When spraying is employed some more effective means must be used to get rid of the spray and fumes. Naturally, a good deal of the vaporized japan or lacquer misses the mark altogether and unless quickly removed would soon contaminate the air to an unbearable extent. Spraying is usually done, therefore, in hoods or cabinets connected to an

exhaust system. These spraying hoods are generally constructed of sheet iron and may be of any size from two or three feet square up, according to the size of the parts to be finished.

Some japans and enamels are air-drying, but a large part of the material now used requires baking at temperatures ranging from 200 degrees Fahr. to 450 degrees Fahr. and inasmuch as the production of a finish of this nature depends upon the proper control of the baking operation it is easy to see that the ovens are an important part of the necessary equipment.

Enameling Ovens

The old-time ovens were rather crude, judged by present standards, and were often fired with coal or coke. In fact this is still the practice in some small installations. The difficulty of maintaining sufficiently close temperature control and the frequency with which the work was spoiled or its appearance greatly injured by the dust which was an inevitable consequence of the use of such fuel gradually led to the adoption of other means for heating the ovens. At the present time steam, gas and electricity are employed for this purpose.

Steam heat is clean, and under the proper conditions may give satisfactory service, but it has the disadvantage that temperatures much above 300 degrees Fahr. demand the use of high steam pressures. Consequently such ovens are not well adapted to quick baking at high temperatures. Furthermore, the steam coils take up space and it is often difficult to obtain a uniform temperature throughout the oven.

Several types of gas-fired ovens have been developed and there is no doubt that with a properly designed oven operated under intelligent supervision it is possible to turn out satisfactory work. Many gas ovens, however, possess certain inherent and objectionable features. Difficulty of controlling the temperature is one drawback. Then there is always the danger of fire, since the vapors given off by japanned parts during baking are highly inflammable. Furthermore, the baking of japan is a chemical as well as a physical process; there is an absorption of oxygen by the coating, with consequent oxidation and hardening of the oils, in addition to the simple evaporation of the volatile portion of the japan by the heat. This means that if the best sort of film is to be obtained there must be a plentiful supply of oxygen present during the baking. Plainly, when the products of the combustion of the gas or other fuel are allowed to get into the baking chamber they are certain to exercise a deleterious influence on the japanned work.

The electrically-heated oven has been designed in an effort to overcome the defects in other oven types and, although much experimenting has been done in order to gain the necessary knowledge, progress has been rapid. The reason for this success is to be found in the fact that with electric ovens any desired set of conditions can be produced definitely and at will; the variable factors present in the old-style ovens have been either eliminated or brought under control and the baking of japan or other material, therefore, has been made an exact procedure. The time required for baking usually can be reduced by the use of an electric oven and the quality of the work improved to an appreciable extent. Perhaps the best evidence that this is true is to be found in the fact that so many large concerns, making everything from automobiles to brass beds, have installed equipment of this character. Although, unit for unit, electricity costs more than gas, the increased production, lower rejections and other factors which attend its use for baking often make an actual saving possible.

Oven Construction

Baking ovens are of three general types. The first, the kiln or box type, is simply a chamber with insulated sides and ceiling provided with the necessary heating coils and an exhaust system or other means for ventilating. Ovens of this type may be either hand-loaded or truck-loaded, which means that in the first instance the work is carried in and hung on hooks or other supports; in the other case the parts to be baked are placed on an iron truck which is then pushed into the oven and left there until the baking is complete. The hand-loaded oven is the most inefficient type. Carrying the work into the oven a few pieces at a time does not make for speed or efficiency and there is the further decided disadvantage that after baking the temperature must be allowed to fall before the workmen can enter and remove the parts. By the time the oven has been emptied and a new load put in the temperature will not be far from that of the room in which it is located; it is then necessary to bring the whole up to the baking heat again. Obviously, the loss of heat is enormous, to say nothing of the time lost in waiting for the oven to heat and then cool off each time.

When trucks are used the efficiency is considerably higher; while one load is baked other trucks can be loaded and unless the oven is large enough to contain a number of trucks it is necessary to keep the doors open only a comparatively few minutes while the baked parts are being pulled out and another load pushed in.

Continuous Baking

The semi-continuous conveyor type has a door at each end with a conveyor, usually a continuous chain, passing through the oven. In operation, a load of work is dipped and hung on the conveyor; after it has dripped for a sufficient length of time the conveyor is started up and the work run into the oven, where it remains until baked. In the meantime, another load of parts has been dipped and hung up and when the first load is sufficiently baked the conveyor is started up again and these parts run out of the oven, the second lot taking their place.

Because the doors of the oven must be opened wide while the work is being changed there is a considerable cooling effect, with consequent loss of heat, so that on the whole the efficiency of this type oven is about the same as that of the truck-loaded kiln type.

As the name indicates, the continuous conveyor oven is one through which a conveyor passes continuously. The parts are hung upon the conveyor and carried into the oven, baked as they go along, and finally removed at the opposite side. There is thus a steady stream of work entering and leaving the oven, the temperature of the oven, the speed of travel and the length of the oven being such that the parts are thoroughly baked when they leave the oven. The doors are open all of the time to prevent loss of heat and the escape of smoke and vapor into the room; the oven is constructed so that an air seal is obtained around the openings, or an exhaust fan is placed at the proper point to secure an air balance and at the same time to provide the necessary ventilation.

The design of the heater units employed in ovens varies somewhat in the different types, but they consist essentially of a ribbon or other form of a high-resistance alloy, supported on a suitable framework of iron. This resistance becomes heated when a current is passed through it. Eleven heaters usually are designed for operation at 110-120 volts and are rated at 2-3 kilowatts. Although they are ordinarily installed along the walls of the oven, they may be placed on the floor or even on the doors, in case such action is necessary to maintain a uniform temperature throughout the oven.

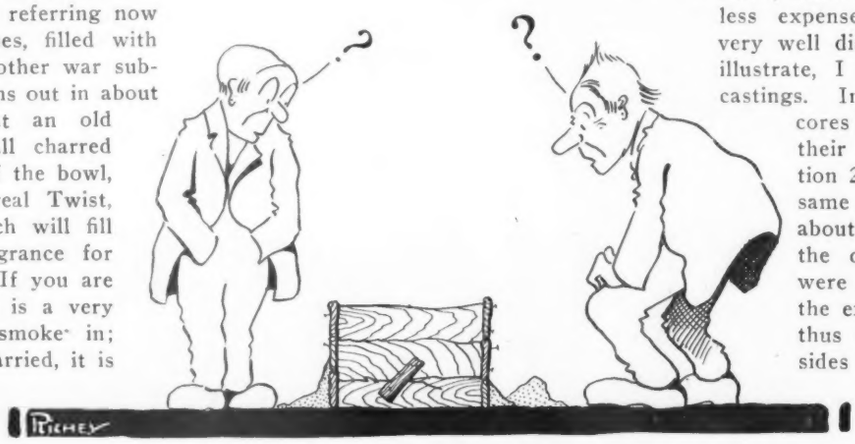
Bill Smokes and Tells About a Grate Bar

By Pat Dwyer

THOSE of you who have read that charming classic "Lorna Doone," will remember that big John Ridd was of the opinion that there were only three places and circumstances in and under which, a pipeful of tobacco could be smoked in perfect comfort. You must hand it to John; he showed rare good taste, both in the selection of places for smoking, and other things. I think, however, that he was too particular in limiting himself to three places; for when you come to think of it, there are very few places, or circumstances in, or under which, a smoke cannot be enjoyed. I am not referring now to brier root pipes, filled with chopped hay, or other war substitute, which burns out in about five minutes; but an old corn cob pipe, all charred around the top of the bowl, filled with Montreal Twist, a pipeful of which will fill the air with fragrance for nearly an hour. If you are unmarried, a bed is a very good place to smoke in; but if you are married, it is something altogether different. For some unaccountable reason, most women have an antipathy for tobacco. Perhaps it is because their minds are cleaner than men's; and I suppose the reason their minds are cleaner is because they change them so often. Considered from the viewpoint of domestic harmony, I would say offhand, that the habit of smoking in bed would be classed as a poor risk.

Well, anyway, I was sitting in an old rocking chair last Sunday, with my feet cocked up at a genteel angle on another one, having a quiet draft of the weed, when old Bill blew in. I found another pair of chairs for him, and when he was comfortably settled, he heaved a sigh, and said:

"This is the life, Sunday was meant for a day of rest. I was boss of a shop for three years one time. It was a foundry in connection with an iron and steel plant. We cast about 40 tons of iron, 5 tons of steel and 2 tons of brass every day. As it was all either repair or new construction work, most of it was always wanted in a hurry, and as a result there was a gang of men out nearly every night and every Sunday. I worked so much overtime during those three years that I never want to hear the word again. It was a great shop to learn and practice short cuts. As a great deal of the same work came in week after week, there was a fine opportunity to try out different ways of making it. In the course of time most of the methods became standardized, but there was always new work coming in and a chance to adapt some of the methods already worked out on other jobs.

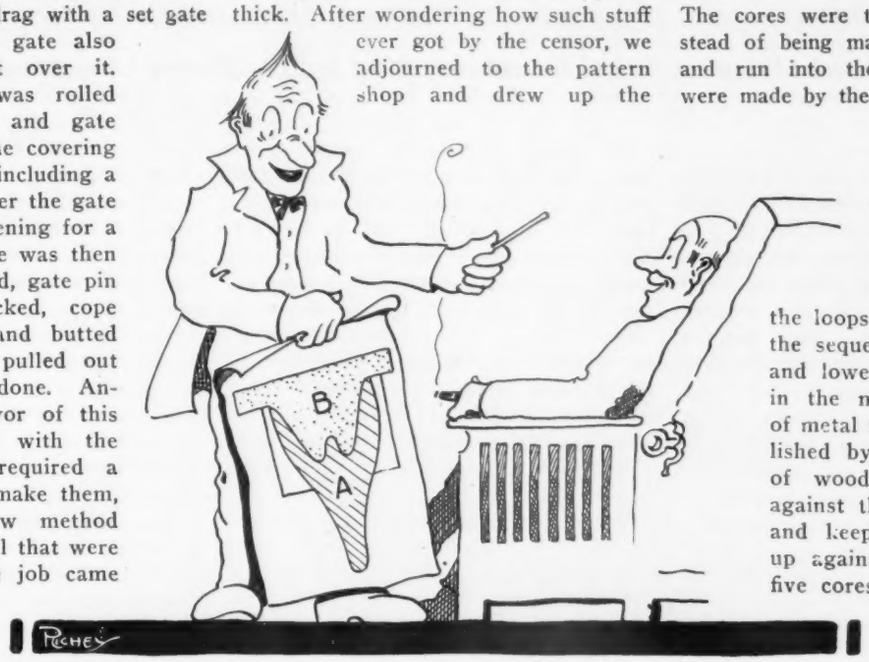


HOW DID IT GET BY?

"The boss patternmaker was a gentleman; by which, of course, I mean that he was always willing to listen to suggestions from the foundry. He not only listened, but he sometimes adopted, and very often improved on the same, for he was, as became his nationality, a canny lad. It makes a lot of difference whether the pattern shop and foundry work in harmony or not, when each is willing to concede a point; when it appears that the method proposed by the other is the more likely to prove in the interest of the firm. Take the question of whether it is better to make a job all green sand or to introduce cores in some parts of it. There are lots of cases where it is really necessary to use dry sand cores; there are others where they are used to facilitate molding, or to insure dangerous parts of the mold; and there are other cases, where their use is a needless expense and they could be very well dispensed with. Just to illustrate, I will tell you of two castings. In one case, dry sand cores were introduced, and their use increased production 200 per cent and at the same time cut the cost about the same amount. In the other, dry sand cores were changed to green sand, the expense of drying being thus done away with, besides getting a better looking casting. The first case was a patent grate bar, 5 feet 6 inches long with a double groove, 2 inches deep all along the top. Here I'll make you a sketch of it, and that will make the idea clearer than half an hour's talking; *A* is a section of the oiling bar, and *B* is the core. The patterns were first made the shape of the finished casting and the grooves had to be lifted in the cope. They were difficult to get a lift from; it was a hard shape to make and unless the iron was just so, they would not run properly in the sharp edges. The loss averaged 10 per cent.

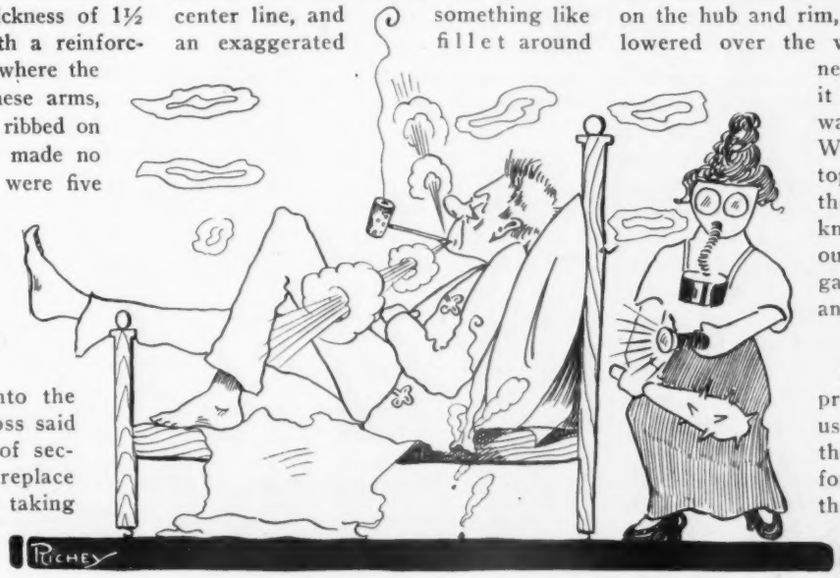
"After changing the pattern, the production was increased 200 per cent and the loss was practically negligible. The covering core box was only half the length of the pattern; this was to fa-

cilitate making and handling. No rods were used in the cores and a boy could make enough in half a day to last a molder all day. The three patterns were rammed up in the drag with a set gate at the end. This gate also had a core print over it. When the drag was rolled over the pattern and gate were drawn out, the covering cores set in place including a short plain core over the gate with a 1½-inch opening for a gate pin. The cope was then put on and clamped, gate pin set, the bars tucked, cope filled with sand and butted off, the gate pin pulled out and the job was done. Another point in favor of this method was that with the original way it required a skilled molder to make them, while by the new method handy men were all that were necessary. As the job came in regularly in orders of 100 at a time, the the saving amounted to quite an item. The other job I spoke of would not go in the 'A' class, but I think it would be quite safe to class it as 'B,' or maybe 'B-2.' There were only two to make, but the patternmaking was reduced to a minimum, and there was no expense for drying the cores. It was a section of a road roller; a kind of pulley, if you like, 6 feet in diameter, with a 14-inch face; a thickness of 1½ inches in the rim and with a reinforcing rib around the inside where the arms joined the ribs. These arms, five in number, were also ribbed on both sides. Of course, it made no difference to us if there were five arms or 15, but it gave the wheel an odd look. I guess the lad who designed it was not attending to his knitting and dropped a stitch. Well, they rolled this queer looking cripple into the yard one day and the boss said to me: 'Make a couple of sections for that, Bill, to replace the broken ones.' After taking a look at it all over, I went and got the patternmaker, and we both had a good look at it, and we solemnly agreed that it was a shocking example of designing, patternmaking and molding. It had been made from a whole split pattern, and the poor molder who made it must have had his own troubles, for there was evidence all over it, where he had patched up the mold, and being evidently a cautious individual he had left lots of clearance all over the joint. In some places the fins had been ¼-inch thick. After wondering how such stuff ever got by the censor, we adjourned to the pattern shop and drew up the plan of campaign. We decided to sweep-up the outside and make the inside with cores, and to cover the rim with a row of cake cores. A sweep and core box were accordingly made, both simple affairs and only requiring a few hours. The core box, 7 inches deep, had a half pattern for the arm fastened to the bottom exactly on a center line, and something like an exaggerated fillet around the bottom of the rim to form the reinforcing rib which ran around the wheel on the inside.



BILL ILLUSTRATES

"Ten arbors were then cast in open sand, with two lifting loops in each, five with the loops looking up and five with the loops looking down. A hole was dug in the floor, the spindle set and a level bed swept to form a seat for the cores. The outside face of the mold was then swept-up and finished. The cores were then rammed, but instead of being made in the core room and run into the oven to dry, they were made by the molder alongside the job in green sand. The first five were made and turned over on a bottom-board, and the core box drawn. They were picked up by the loops cast in the arbor in the sequence they were made and lowered into their places in the mold. The thickness of metal in the rim was established by holding two pieces of wood, 1½ inches thick, against the wall of the mold, and keeping the cores close up against them. The other five cores were lifted directly out of the box by their loops which in this case came flush with the top of the box. They were located on top of the other cores by the same two sticks in front, and having the sides coincide with the cores below them. They all fitted so snugly that it was only necessary to run a lifter across the joints to make it look like one body of sand. The center core was then set, covering cores placed on the hub and rim, a plain iron cope lowered over the whole thing, runners made up, and it was cast. There was not a fin on it. Well, so long, old top, I must be on the way." Old Bill knocked the ashes out of his pipe, gathered himself up and blew away.



SMOKING IN BED IS A POOR RISK

A method for improving coke for use in furnaces is the subject of a foreign patent. The theory is that by reason of its many large pores, coke burns too quickly and to overcome this disadvantage the coke is broken to a uniform size suited to the character of the work. Then it is treated with a slurry consisting of a watery mixture of coal dust and loam or clay, thereby filling the pores making a fuel similar to anthracite.

Making Manganese Bronze With Impure Metals

Ordinary Impurities Encountered in Nonferrous Materials Offer No Serious Obstacles When the Same Elements Are Added to Effect Desired Composition

By P E McKinney

DEVELOPMENTS in engineering during the past decade, particularly as applied to marine construction, mining machinery and other purposes in which corrosion offers a serious problem, have created a large demand for a nonferrous metal highly resistant to corrosion. This material had to be useful in general construction work as a substitute for steel without materially decreasing the factor of safety or increasing the weight of the various parts. To obtain the combination of desired properties many compositions have been proposed and used with excellent success. At the present time probably the most popular and most widely used combination is the nonferrous alloy commonly called manganese bronze. This is nothing more than a high brass to which have been added, by the proper method of alloying, comparatively small percentages of aluminum, iron, or manganese. The other constituents are added with the definite purpose of strengthening the alloy and rendering it more dense and close-grained than the average yellow brass casting.

In the manufacture of manganese bronze a great deal has been said about the importance of using only the highest grades of raw material and the beneficial or detrimental effects, as the case may be, of various impurities, as well as the importance of adding the ingredients according to various formulas proposed. In most of these cases the literature on the subject has dealt principally with the manufacture of this alloy from virgin metals and raw materials of the highest purity. Shortages recently have existed in raw materials needed for many products entering into the various branches of engineering work, particularly the nonferrous metals, and during the next few years of reconstruction the country will be flooded with many by-products and much scrap resulting from the extensive operations carried on during the war, when scrap and by-products could not be handled in sufficient volume to effect rapid production. These facts constitute conditions that make a project looking toward the efficient utilization of materials at hand well worth while.

When manufacturing manganese bronze or a similar alloy from raw materials there is intentionally added a percentage of iron, which is generally conceded to be one of the objectionable impurities in nonferrous scrap. In addition to iron, aluminum and manganese are added, and sometimes tin in small quantities. All of these elements if present in the virgin metals ordinarily used in nonferrous foundry practice would be considered detrimental impurities. The composition of the average manganese bronze is as follows:

	Per cent
Copper	57 to 59.0
Zinc	38 to 40.0
Iron, manganese, aluminum, tin	0.25 to 1.0
Lead	0.1 to 0.5

This composition shows clearly that there is no necessity for the use of high-grade raw materials, provided methods of manufacture can be devised to produce the proper refinement of the finished product. The ordinary impurities encountered in nonferrous materials offer no serious obstacles when the same elements must be added in considerable percentages to effect the desired composition.

In the manufacture of manganese bronze it has been found possible to utilize what would ordinarily be termed material of low grade, such as, skimmings from the foundry, particularly skimmings and dross ordinarily recovered from brass rolling mills or cartridge-case plants, zinc dross recovered from galvanizing plants, aluminum turnings that are ordinarily unrecoverable without serious loss and deterioration of the product due to oxidation, etc., and other by-products and scrap metals that ordinarily are not usable as remelting scrap in foundry practice. The manufacture of high-grade manganese bronze from materials of this class, however, cannot be attempted in crucible furnaces, or practiced only on a comparatively small scale. The reactions require a reverberatory or other furnace in which it is possible to accumulate a bath of considerable volume and in which the charge of metal can be worked in the same manner as in other refining processes producing on a large scale in open-flame furnaces. The idea is so to compound the various materials available as to cause one to react with the other to the mutual benefit of all the ingredients going into the charge. A typical charge for operating a reverberatory furnace in the manufacture of manganese bronze is as follows:

	Pounds
Yellow brass machine shop turnings	1250
Zinc dross from galvanizing plant	400
Aluminum turnings	30
Recovered scrap zinc	400
Dross and skimmings from billet and slab plant	2000
Foundry floor scrap and skimmings	650
Hardener made by melting scrap copper and manganese in equal proportions	250
Charcoal	75
Common salt	80

With a knowledge of the general chemical composition of each in-

Table I

Analyses of Ingots from Reverberatory Furnace

	Copper, per cent	Zinc, per cent	Tin, per cent	Lead, per cent	Iron, per cent	Aluminum, per cent	Manganese, per cent
Heat A	57.95	39.08	0.35	0.42	0.83	0.59	0.77
Heat B	57.18	39.54	0.51	0.34	1.04	0.48	0.91

Table II

Physical Values of Sand Castings from Remelt of Ingots

	Tensile strength, lb. per sq. in.	Yield point, lb. per sq. in.	Elongation, per cent
Heat A	67,700	46,300	22.1
Heat B	72,100	50,400	21.0

From a paper presented at a recent meeting of the American Institute of Mining Engineers. The author, P. E. McKinney is chemist and metallurgist of the naval gun factory, Washington.

gredient going into the charge it is easy to produce a manganese bronze that will have the desired composition and will require no other treatment than, possibly, the addition of a little zinc when remelting for casting purposes.

When handling a charge such as that shown, advantage is taken of impurities, such as the iron existing in the zinc dross, the small percentages of tin in the machine shop turnings, etc., in figuring the final desired analysis of the alloy. It is well-known that such materials as zinc and foundry skimmings, both of which contain dirt and oxides, cannot be recovered in a usable condition when melted separately in crucibles or by any of the ordinary methods of melting material, without an excessive loss due to volatilization. But when the well-known reactions occurring in the manufacture of old-fashioned calamine brass are taken into consideration, it can be seen how the combination of zinc, dross, brass skimmings, and other highly oxidized materials melted in contact with charcoal will produce an alloy nearly as well deoxidized as the average high-zinc brass. Contact, while in a molten or semimolten state, of metallic copper and partly oxidized zinc in the presence of charcoal develops a condition extremely conducive to a thorough deoxidation and alloying of all the metallic ingredients. This reaction, together with the well-known deoxidizing effects of aluminum, manganese and iron, which are part of the charge, contributes to the production of thoroughly deoxidized and dense material. Salt is used as a flux on account of its excellent properties for gathering and fluxing off the dirt and the oxides of iron, manganese, etc.

In charging the furnace, it is the usual practice to place the manganese hardener in the bottom and on top of it to place the cartridge-case dross and zinc dross with a layer of charcoal, after which the foundry skimmings and turnings are added and the charge is melted, with occasional rabbling to clear the metal and bring all the ingredients into intimate contact. When the bath is melted, the aluminum scrap is added and the necessary zinc additions are made, after which the charge is allowed to cool slightly in the furnace and is poured into ingots for remelting purposes. Analysis is made of these ingots to determine the necessity of adding zinc or otherwise correcting the composition by the mixture of several heats in order to obtain the desired composition.

As instances of what can be obtained, the results of tests are given in accompanying tables. These tests were made on castings produced by the method described from initial charges of raw material practically identical with the typical charge given.

In addition to the excellent properties shown in the tensile tests, the material corresponds in every other physical respect to so-called high-grade manganese bronze produced from virgin metals, has a fine uniform fracture with a tendency to silky grain in many cases and shows toughness and resiliency equal to any other grades of manganese bronze examined.

Some objection may be raised to the use of by-products and scrap material in the manufacture of manganese bronze because the lead content of some of these by-products is quite high, and will introduce into the alloy quantities of lead higher than are desired. It is believed, however, that the results of tests made from time to time on manganese bronze containing in some cases a considerable percentage of lead have shown conclusively that lead within reasonable limits is not detrimental. No concrete cases have as yet been cited in which, other things being equal, lead under 0.75 per cent has shown seriously detrimental effects on the alloy. All the samples on which physical tests are given contained percentages of lead ranging from 0.25 to 0.50 per cent, yet none of them show in the test results any detrimental effects due to the presence of this impurity. It is believed that the tolerance of a slightly higher content of lead in specifications for manganese bronze, in general, would serve admirably as a conservation measure for high-grade virgin material. This has been proved.

Table III

Physical Tests of Sand Castings from Manganese Bronze Produced by Process Described

Tensile strength, lb. per sq. in.	Yield point, lb. per sq. in.	Elongation, per cent
67,300	45,800	29.9
66,400	37,400	30.9
67,700	41,200	24.5
72,200	34,100	24.5
67,900	33,900	28.1
72,600	36,700	23.4

HOW AND WHY IN BRASS FOUNDING

By Charles Vickers

What Monel Metal is and How it is Used

What is Monel metal and how is it used in foundry work?

Monel metal is a natural alloy of copper, nickel and a small amount of iron. Roughly, the proportions are copper, 30 per cent; nickel, 68 per cent and iron, 2 per cent. The alloy is smelted with very little refining from the Sudbury ores of Canada, and no competition is possible by making the alloy from new metals, on account of the cost of the nickel. It must be made either from scrap Monel metal, or by obtaining new metal in ingot form from the producers. Its melting point is 1360 degrees Cent., or 2480 degrees Fahr. Its specific gravity, when cast, is 8.87; weight per cubic inch cast, is 0.319 pound. Its coefficient of expansion between 20 to 100 degrees Cent. equals 0.00001375 per degree of Cent. Its electric resistivity is 256 ohms per mil foot; its temperature coefficient is 0.0011 per degree of Fahr. Its electric conductivity when compared with copper at 100 is 4 per cent; its heat conductivity is one-fifth of that of copper; shrinkage, ¼-inch to the foot; hardness, cast, 20 to 23, scleroscope. The physical properties of castings are: Yield point, 37,427 pounds per square inch; ulti-

mate strength, 78,236 pounds per square inch; elongation, 38.5 per cent in 2 inches; reduction of area, 34 per cent, and modulus of elasticity, 22,000,000 to 23,000,000.

The metal causes difficulties in the foundry because of its high melting point; these difficulties are incident to obtaining such high temperatures in ordinary brass melting furnaces, and the tendency of the metal to absorb gases while it is being melted, coupled with the fact that the temperature of the metal, when ready for pouring into the molds, is too high for ordinary brass molding sand, the result being that it fuses, evolves gases, firmly sticks to the castings, and generally acts in a manner that produces unsatisfactory work. To overcome this, a facing such as steel founders use should be employed. This facing will withstand the high temperature of the metal. It consists of silica sand bonded with fireclay and molasses water. Merely use enough fireclay to bring the free sand to the plasticity of molding sand. The facing is best when milled in a suitable mill.

To improve the casting qualities of the alloy, aluminum is added up to 0.5 per cent. To deoxidize the alloy, magnesium and manganese are used together and produce a better result than either of these elements alone. Certain alloys of aluminum bronze are formidable competitors of Monel metal as far as physical qualities are concerned, as some of these alloys have between 90,000 and 100,000 pounds tensile strength with between 30 and 40 per cent elongation in the cast condition, and are easy to melt and to cast. If aluminum bronze can be used instead of Monel metal, less trouble would be encountered in the foundry.

Kerosene is Unsatisfactory

We have experienced considerable difficulty in the operation of an open flame cylindrical furnace. We cannot get the metal sufficiently hot to run thin castings and they are dirty and filled with holes. We are trying to melt with kerosene. We use 40 pounds pressure on the oil tank, our blower gives 9 ounces pressure. We charge about 200 pounds of good brass scrap and recover about 160 pounds of metal in castings, sprues, gates, etc. We use borax for a flux and a very small amount of phosphor tin.

Kerosene is seldom used as fuel for melting brass and the difficulty in this case may be largely due to the fact that the burners were not designed for this kind of fuel which is more fluid than the fuels ordinarily used in such furnaces. It also requires a large amount of air to insure complete combustion. The fact that the temperature of the metal is too low would indicate that insufficient air is being used to burn the oil, and if this is the case and the time of melting is greatly prolonged the metal will be oxidized by the air leaking into the furnace in spite of the reducing character of the flame. This would account for the heavy metal losses, and for the dirty and porous castings. Pine blocks probably were used by the demonstrator to form charcoal and to keep down oxidation. It would be advisable to use crude oil, but if this cannot be obtained, considerable experimentation will be required to learn how to use the kerosene in order to get the best results. If the kerosene is sprayed from the burner with high pressure air, and low pressure air is admitted to insure combustion, the results might be considerably improved. A flux should also be used. A suitable flux for this purpose should consist of equal parts of ground coke, fluorspar, sand or lime. Borax is an expensive flux and may be omitted. About 1 per cent of phosphor tin is an excellent deoxidizer and its use should be continued, or phosphor copper may be substituted.

Hecla and Government Bronzes

We have an inquiry for Hecla bronze and we would like to obtain the formula for this alloy. We also have an inquiry for Government bronze, and would like to have this name defined. We have several formulas for alloys known as Government bronze and do not know how to make a selection.

Alloys which have been favored with proprietary names such as Hecla bronze, Graney bronze, etc., are liable to differ in composition when obtained from different sources, because foundrymen called upon to produce these alloys frequently use their own formulas, often without the least regard to the original compositions of the alloys produced under these names.

An analysis of one *Hecla* bronze follows: Copper, 85.43 per cent; tin, 8.26 per cent; lead, 2.64 per cent; iron, 0.12 per cent; zinc, 3.40 per cent and phosphorus, a trace.

The situation with reference to Government bronze is different, as by general custom this term has been applied to what is also known as 88-10-2, that is, copper, 88 per cent; tin, 10 per cent and zinc, 2 per cent. This alloy probably obtained the name of Government bronze because it is in high favor with the various government departments using such alloys, regardless of its adaptability for the work for which it may be specified. The alloy was originated by J. Dewrance, of England, and requires careful handling, particularly with reference to the temperature at which it is poured into the molds if sound castings are to be obtained. The best casting temperature is 1200 degrees Cent. (1992 degrees Fahr.), and if poured, for instance at 2550 degrees Fahr. the castings will be porous. The analysis of the alloy given for *Hecla* bronze could well be substituted.

Porosity in Bearing Mixtures

We are making bearings and cylinders, ranging in weight from 15 to 260 pounds, from an alloy consisting of copper, 88 per cent; tin, 10 per cent and lead, 2 per cent. We have considerable trouble with this mixture. Porous areas exist under the risers. When the mold is poured, the risers, instead of shrinking, rise, sometimes as much as an inch. The porosity does not appear all through the casting, which makes us conclude that the melting is not at fault. Some of the copper we use also is raised in the center of the ingot, and we have been of the opinion that it might be advisable to ingot the new metal and remelt for the castings. We melt in a tilting, coke-fired furnace and heretofore, our losses have been extremely low.

A microscopic examination of what appears to be the sound part of the casting will reveal that the porosity extends throughout the entire alloy, and is merely worse near the risers. To satisfactorily explain the cause of this porosity would require many printed pages; briefly, we will state that the alloy is a very poor one for casting purposes, and while it has been cast soundly, it is capable of causing so much difficulty of the kind outlined that it does not pay to use it without modification. If 2 per cent of zinc is added, and the amount is deducted from the percentage of copper, the resulting alloy will respond to proper foundry treatment, and the castings will be free from the defects mentioned. The trouble is not due to oxidation alone, but to a complex reaction between the lead, copper, oxygen and sulphur, when there is a certain balance established between the two latter elements. Disturbing this balance, makes for sound castings, and this disturbance can be produced by adding zinc which reacts with the sulphur to form zinc sulphide which volatilizes and lowers the sulphur, or the oxygen can be lowered by phosphorous, but the latter method does not work with the same certainty as the addition of zinc. When the lead is considerably in excess of the tin as in the alloy containing 15 per cent lead and from 5 to 9 per cent tin, there is little difficulty from gases; therefore, if the castings can be made of this alloy, little difficulty can be anticipated.

A good mixture would be copper,

76.75 per cent; phosphor copper, 0.25 per cent; tin, 8 per cent and lead, 15 per cent. This is a better bearing alloy than the one used, and it is suitable for bushings.

If a strong alloy is required, that can be used also as a bearing, the following can be relied upon: Copper, 89 per cent; tin, 6.50 per cent; zinc, 2.50 per cent and lead, 2 per cent.

If the present alloy cannot be changed, add 0.5 per cent phosphor copper, and if this is unsuccessful, there will be no alternative but to change the mixture and not less then 2 per cent of zinc should be added.

Difficulties Caused by Oxidation

Recently we have experienced considerable trouble with our brass castings. We melt in a gas-fired furnace, using an alloy of copper, 81 *per cent; tin,* 8 *per cent and lead,* 10 *per cent. The alloy becomes pasty or gummy and will not run the castings. We use all new metal and when we put the lead into the copper, the mixture starts to boil like water; after the tin is added it gets thick and pasty. The other day we purchased ingot metal to this formula, but had the same difficulty. Can you suggest a remedy?*

The reason the metal gets pasty is that it is badly oxidized during the melting process. The lead makes the copper fluid because it lowers the melting point; all copper-lead combinations are characterized by great fluidity and liveliness. The boiling is caused by the lead partly oxidizing and vaporizing, the effect being the same as steam rising from boiling water. When the tin is added it takes some of the oxygen from the copper and forms tin oxide, and the metal becomes pasty because the tin oxide is very infusible and is held in suspension in the metal. The difficulty is caused by a wrong adjustment of gas and air; the latter should be turned off a little, even if melting is slower and more gas is used. On top of the metal use a cover of bottle glass and charcoal, or ground anthracite coal, and if the metal becomes pasty throw on common salt, which will liberate the tin oxide from the metal so that it rises to the surface and eliminates the pasty condition. After using salt, however, it will be necessary to add a little phosphorous; about 0.5 per cent of the 15 per cent phosphor copper should be used to deoxidize the metal. It is also possible to use magnesium, preferably added as a 10 per cent magnesium copper. To a badly oxidized alloy it will be necessary to add 1 per cent of the 10 per cent magnesium copper. Use stick magnesium and melt 90 per cent of copper under a cover of magnesia purchased at a drug store. Cover the metal with about ½ inch of magnesia and then toss the pieces of magnesium on top of the magnesia covering and stir them into the copper using a stirrer made of a slab cut from the side of an old crucible and attached to a handle. The magnesium sticks should be broken into four pieces by nicking them on one side with a cold chisel, then striking them with a hammer while the stick is held in the vise with the nick just showing above the jaws.

Add 10 per cent magnesium, one length at a time and stir between each addition, and when it has been all added, pull the pot and pour into ingot molds that have been covered with an iron plate, except a little part of one end into which the alloy is poured. When the ingot is poured, cover it to exclude the air. Have the molds cold, but perfectly dry. The oxidized metal made by the present methods produces poor bearing alloys, as the contained tin oxide effects a result similar to emery mixed with the metal, so far as its action on the shafting is concerned.

Type of Furnace to be Installed

We would like to obtain information regarding the melting of brass, bronze and aluminum in crucible pit furnaces, using oil instead of coke for fuel. We are considering the installation of a battery of four furnaces, using No. 80 *or* 100 *crucibles and melting about* 2000 *pounds of metal daily. Would it be possible to set the furnaces on the foundry floor with the oil and air pipes in a covered trench? Is a brick or steel stack required and if so what should be its diameter and height? Would a hood over the furnaces be satisfactory instead of a stack? What size blower would be required to supply the air? Do you consider the use of oil as fuel, better and cheaper than coke?*

Information on the subject of melting nonferrous alloys can be obtained from *Bulletin No.* 73, Bureau of Mines, Washington, D. C. The bulletin is entitled "Brass Furnace Practice in the United States," by H. W. Gillett, and its cost is 45 cents. It contains 298 pages, and is a mine of information on this subject. If the furnaces are of the non-tilting type, it would not be advisable to set them on the foundry floor as in this case a working platform would have to be erected with steps leading down to the floor. The height of this platform should be about 12 inches below the tops of the furnaces, and all metal would have to be carried up these steps to charge the crucibles. When the crucibles are pulled from the furnace and are carried to the skimming hearth, they are at a dangerous height above the floor. Furnaces from which the crucible has to be removed for pouring, should be placed in a pit so that the tops of the furnaces are either on a level with the foundry floor, or about 12 inches above it. When the molding room is situated above the ground floor, the furnaces are set in a boiler plate tank, which is suspended from the floor and the walls of the building, and must be securely installed.

Tilting furnaces usually are set on the floor of the foundry; the charge is fed into a hopper, and movable platforms are used to enable the furnaceman to work over the furnace, if this becomes necessary. To remove the metal, the furnace is tilted and the bronze is poured into ladles. Either coke-fired or oil-fired furnaces can be used and both are quite efficient. A stack would be advisable in the case of the crucible pull-out furnaces, and either a brick or a steel stack may be used. In the case of oil-fired furnaces it is not necessary to extend the stack more than a few feet above the roof. A hood also will be necessary. In the case of tilting furnaces, a stack is rarely used, but a hood is required. It is important that the outlet of the hood extend up straight and without bends, and it should be of a sufficient size to carry off the fumes. These details are usually supplied by the maker of the furnace selected, as it is better to purchase some known and tried type of furnace than to experiment.

The question as to whether oil or coke-fired furnaces should be installed is largely one of local facilities for obtaining the fuel; both types are employed successfully, and even for tilting furnaces both fuels are used.

Low Shrinkage Pattern Metal

Kindly furnish us with a formula for a good, nonshrinking pattern metal.

An alloy that is absolutely nonshrinking is an unknown quantity, but some alloys shrink very much less than others. A good pattern alloy consists of zinc, 50 per cent and tin, 50 per cent. This alloy has very little shrinkage and is the best that can be expected with such alloys. If from 1 to 2 per cent of antimony or bismuth, the latter being preferred, is added in place of an equal amount of zinc, the slight shrinkage is further lessened. If plaster of paris can be used for the patterns it will be possible to get duplicates the same size as the originals, but in the case of metal patterns, this is impossible.

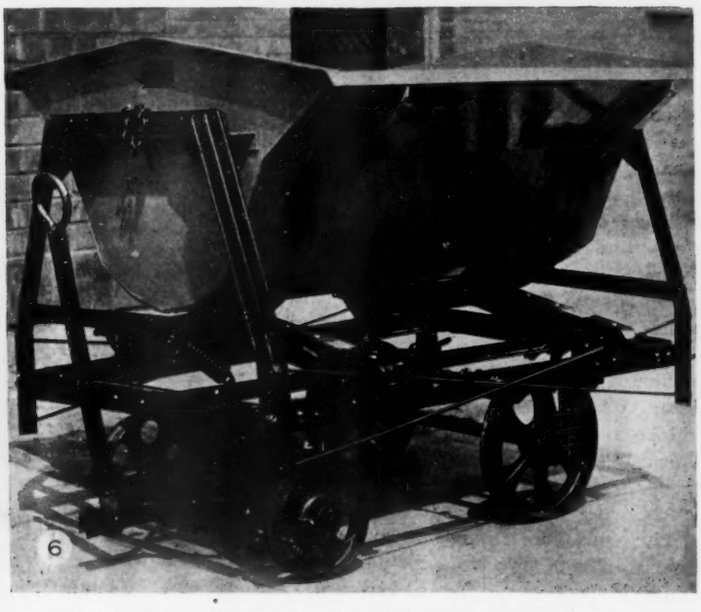


FIG. 1—TRACTOR AND TRAILER HAULING SCRAP IN A FOUNDRY YARD. FIG. 2—HOW THE TRACTOR IS UTILIZED TO HAUL HEAVY LOADS. FIG. 3—TAKING ON A LOAD OF PIG IRON. FIG. 4—TYPE OF DUMP CAR USED FOR HAULING SCRAP SAND, ETC. FIG. 5—HAULING A LOAD OF SCRAP IN DUMP TRAILERS. FIG. 6—CLOSE VIEW OF DUMP CAR USED IN FOUNDRY WORK

Tractor and Trailers Reduce the Haulage Costs

Tractor Trains Run Anywhere Without Tracks—The Trailers Follow the Tractor Through the Practical Application of a Simple Geometrical Principle

OWING to present-day cost of labor, the problem of transporting sand, scrap, pig iron and castings in foundries assumes serious proportions. This is especially true in foundries making light and medium weight castings as these have to be handled many times, especially in malleable iron shops. Industrial railways, consisting of narrow-gage tracks upon which individual cars are pushed by man power, of course, have been utilized in casting plants for many years. With the object of perfecting a system that could operate to advantage in any part of the foundry or yard, the Mercury Mfg. Co., Chicago, has developed a method of hauling materials that operates without tracks. Owing to the absence of tracks, this system can be extended indefinitely on short notice.

The system consists of a 3-wheel tractor which hauls any number of trailers from 1 to 15. The trailers follow the exact path of the tractor through the application of a simple geometrical principle. The cars or trailers are so coupled together that the train can negotiate right angles, turns in narrow aisles or pass through confined places without striking.

The principle involved is simple, as indicated in Fig. 12. The circle represents the arc made by the trailers in taking the curve while the lines *A* represent the fixed axles of the trucks. The wheels are shown at *B*. When the axles start to move, the natural tendency is to follow the lines of least resistance and start in straight courses as shown by the lines *C*, which are tangent to the circumference. These lines intersect midway between the wheels and meet at a point outside the circumference. These lines can be considered as representing drawbars. Thus, when the front set of wheels begins to move, the drawbar pulls the outside rear wheel in and toward the circle forcing it to travel faster than the inside rear wheel. Thus a fixed path is followed because the wheels are always kept tangent to the circle.

Special Hitch is Used

The points where the lines *C* intersect are midway between the lines representing the axles. This principle must be embodied in actual practice, since otherwise the trailers will not follow the route of the tractor. To cause the cars to trail properly, it is necessary that the point upon which the hitch swivels is midway between the fixed axles of two trailers coupled together. This generally involves the design of a special hitch, depending on the type of truck used.

Fig. 7 shows a train of trailers moving a load of castings from one department to another while Fig. 11 shows a train of eight trucks passing through a foundry. In both cases the trains are taking sharp curves. In the case illustrated in Fig. 11 it is necessary that the trailers follow the tractor, otherwise damage might result to the molds shown on the floor. Fig. 10 shows a train of trailers passing through a malleable iron annealing room. In this case the tractor took a snake-like course to avoid two loaded trucks and each trailer passes these obstructions in the same course as the tractor.

An interesting demonstration of how the trailers track is shown in Fig. 8. In this case, several trailers are drawn in a circle through one doorway and out of another. On first thought it would appear that the trailers would collide with the brickwork between the two doors. In practice, however, the trailers follow a fixed route because of the principle explained in Fig. 12.

The tractor that furnishes the motive power is illustrated in Fig. 9. Briefly described, it is a 3-wheel truck driven by a motor which derives its power from storage batteries. The two rear wheels furnish the tractive power while the single front wheel is utilized for steering. This tractor is 69 inches long with a 39-inch wheel base and a 30½-inch tread. The extreme width is 39 inches which permits it to operate in confined places.

The frame is made from a single piece of 4-inch channel iron which

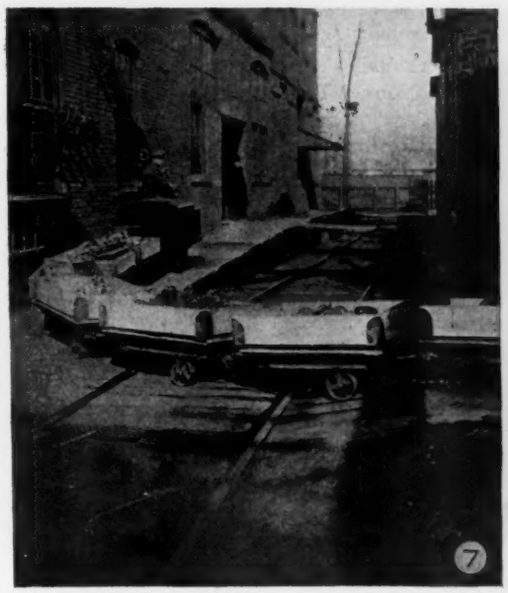


FIG. 7—TRANSPORTING CASTINGS FROM ONE DEPARTMENT TO ANOTHER FIG. 8—OPERATING A TRAIN IN A COMPLETE CIRCLE WITHOUT HITTING OBSTRUCTIONS

FIG. 9—THREE-WHEEL TRACTOR DRIVEN BY STORAGE BATTERIES

is welded to form a continuous piece. Other frame members are 3 and 4-inch channels which are placed and fastened to insure rigidity. The motor is of the series type adapted for hard service and drives direct to the rear axle through worm gearing.

The tractor is equipped with three speeds forward and three speeds reverse, control being had through the medium of a drum-type controller. This controller is located at the front of the machine where it is readily accessible. The wheels are equipped with solid rubber tires.

The rear part of the frame, which supports the batteries, is equipped with springs to absorb the jar due to traveling over rough roads. A brake is provided which contracts on a drum mounted on the worm shaft. This brake is actuated by means of a foot pedal. A novel feature of the machine consists of an automatic braking device. The brake is actuated by a spring controlled by the driver's seat so that the brake is set every time the driver leaves the seat. Through this same arrangement, the controller is automatically turned to the off position, preventing starting.

The tractor is capable of developing a speed of 7½ miles an hour when running without a load and gives a maximum drawbar pull of 600 pounds. Equipped with a 16-cell, lead storage battery, the chassis weighs 2135 pounds. These batteries, when fully charged, it is claimed, are capable of pulling a reasonable load under conditions usually found in foundries for a full 10-hour day, without recharging.

The trucks, or trailers, can be of any practical type. Several are shown in the accompanying illustrations. The trailers shown in Fig. 4 are of the dump type and are adapted for transporting sand, scrap or other materials that can be handled advantageously in bulk. A closer view of one of these trucks is shown in Fig. 6.

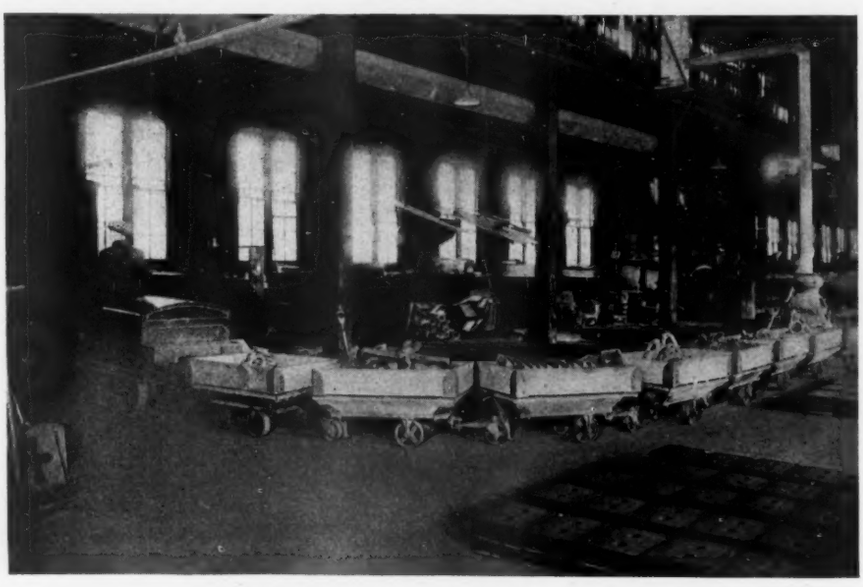


FIG. 11—TRAIN OF TRAILERS OPERATING IN A FOUNDRY

FIG. 10—HOW THE TRAIN TURNS TO AVOID OBSTRUCTIONS

The trucks are coupled together by means of simple hitches either of the bar or chain type. In some cases the handle of the truck can be utilized as a drawbar. When the train is made up and the tractor hitched on the front, the whole unit is designed to proceed around corners, posts or other obstructions and go through doorways and confined places without striking. This feature allows the operator of the truck train to concentrate his attention ahead.

The tractors are used for many other purposes besides hauling trains

of trailers. As a practical illustration, Fig. 2 shows how a large ladle is easily transported. A single trailer carrying castings in a foundry yard is shown in Fig. 1. Another use to which these tractors are often put is for hauling cars on small industrial railways. Fig. 5 shows a tractor pulling two dump-type trailers loaded with scrap while Fig. 3 is a tractor train of three cars about to take on a load of pig iron.

Adolph Stumbles Onto a New Core Compound

"Say, Adolph, listen," said Emil, core room foreman, to the foundry superintendent. "The core flour's all gone and we need some more right away."

"All gone," replied Adolph, "man, you're crazy with the heat. There's a dozen bags in the supply room."

"Got to show me, Adolph," said Emil.

Accordingly 10 sacks of flour were

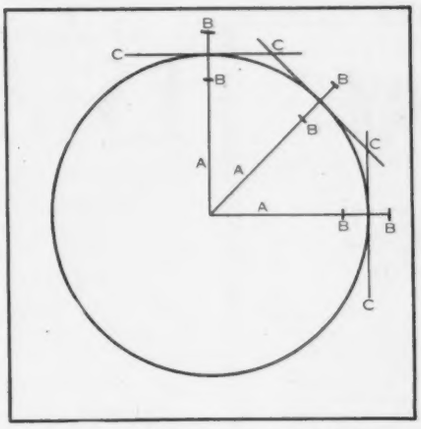


FIG. 12—PRINCIPLE OF OPERATION

pointed out and Emil proceeded with his work. Some days later Bill, the assistant superintendent, approached Adolph and complained that his men were ready to start painting the foundry interior with spraypipes.

"But I can't find the coldwater paint," he said, plaintively.

"Can't find it," said Adolph, "where did you have it?"

"I'll show you," said Bill, and he pointed out the spot where the core flour had been discovered on the previous visit. "But where it went I'll be derned if I can see."

But Adolph knew. Inquiry in the core room revealed that the flour was working well and that the cores made no trouble with the castings. In fact it was a little better *flour* than the foundry had been getting.

Being wise to human nature Adolph held his peace in the core room and at once ordered 10,000 pounds of coldwater paint, a little of which was used to spray the foundry and the rest is core flour of the *highest grade.* It costs about 3 cents a pound against 13 cents for the old style core flour that was used.

"Bill," said Adolph, to his assistant, "give the paint gang a day off. We can stand the expense and I'll have the paint here tomorrow morning."

Manufacturing High Grade Malleable Castings

By J G Garrard

MALLEABLE iron castings are preferred because of their ductility, but many buyers think that they should never be made with heavy sections, due to their false belief that the castings cannot be annealed thoroughly. This idea is still in the minds of men who have been using malleable castings for years. Every effort should be used to correct this impression and convince them that heavy sections can be thoroughly annealed.

This contention, coupled with poor design of patterns, is the greatest difficulty with which the malleable foundryman is confronted.

There is more or less of a trick connected with making malleable castings with heavy sections. First the metal must be made high enough without too great a reduction in carbon, it being a known fact that carbon oxidizes much more rapidly than silicon and can be readily identified in the test piece by the short crystals. This condition with the silicon under 0.50 per cent cannot possibly give good results. The metal, however, can be changed in the furnace with the addition of low-silicon pig iron to increase the carbon.

Gating with heavy shrinkers and close attention to the ribs on any particular casting is very important. Chills can be eliminated in most cases and should be as they do not correct the trouble, but simply drive the shrinkage from one place to another.

We have experimented a great deal with our furnaces in reference to top blast, as it is my contention that excessive top blast not only causes more shrinkage, but produces unsound and weak castings.

Top Blast Pressure Eliminated

We have adopted a method of practically eliminating pressure on the top blast and in doing this we do not have any trouble with high heats, as the firemen cannot force the heat to the extent of excess oxidation.

The blast at the tuyeres shows only 2/3-ounce, and I believe this accounts for the following results:

Test No.	First Iron—Silicon Per cent	Total Carbon Per cent
2	0.90	2.65
3	1.04	2.62
4	1.02	2.56
5	0.92	2.61
7	0.98	2.40
Test No.	**Last Iron—Silicon Per cent**	**Total Carbon Per cent**
2	0.90	2.51
3	1.04	2.61
4	1.00	2.49
5	0.95	2.59
7	0.99	2.42

A furnace run to turn out uniform first and last iron, annealed with the use of pyrometers to insure the proper temperatures, is bound to give a tensile strength of 45,000 pounds and over per square inch with an elongation in 2 inches of 7½ per cent and over. This is a practical material for most uses.

There has been a great deal of confidence placed in castings showing a deep skin. This skin is carbonless iron produced with strong packing which absorbs the carbon from the outside of the casting. Such a skin can be increased by more than one annealing, but it does not show any great advantage over the casting annealed without packing or in a cinder packing.

From a paper presented before the Milwaukee convention of the American Foundrymen's association.

Purchases Electric Furnace

Steel casting equipment including a 1-ton, 3-phase electric furnace has been ordered by the Denver Rock Drill Mfg. Co., Denver, for use in a new steel foundry which was completed about March 1. The furnace has been purchased from the Industrial Electric Furnace Co., Chicago.

Establishes Cleveland Branch

The Independent Pneumatic Tool Co., Chicago, has established a branch office and service station in the Citizens building, Cleveland, under the management of Hayden F. White, who formerly represented this company in the Chicago, Detroit and Milwaukee districts.

The firm name of the Cuyahoga Crucible Foundry Co., W. Ninth and Front street, Cleveland, has been changed to the Alloy Cast Tool Co.

THE FOUNDRY

A semi-monthly journal devoted to all branches of the foundry trade

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Equipment Buying Revived

HIGH labor cost is the compelling factor that is driving foundrymen into the equipment market at a time when least expected. Inquiry is heavier than at any time since the spring of 1917, and it is apparent that casting manufacturers are preparing to counteract constantly mounting labor costs with mechanical equipment. Few industries, taken as a whole, are so poorly equipped with labor-saving devices as that of casting production. There are still several thousand shops in this country in which the benefits of the molding machine are not appreciated. The sand-blast is still an enigma to many. However, continued missionary work coupled with advancing wages will bring about rapid changes in archaic methods of operation. Many new foundry projects also are being undertaken. This indicates that capital has faith in the present and future ability of the industry to return fair profits on the investment. With the exception of the steel casting industry, foundry capacity was not greatly increased throughout the period of the war. This activity in new construction, therefore, must be construed as reflecting only a natural growth.

The Unemployment Hoax

OUR late congress passed into history without making an appropriation for the continuation of the unemployment service of the federal department of labor. Millions of dollars were asked to carry on this work to June 30, 1920, but the measure was talked to death in the closing hours of this memorable session. Although designed primarily to find employment for our returning soldiers and sailors, the efforts of those in charge of this service were directed toward surveys of the extent of unemployment throughout the United States. From the start the validity of these figures was questioned because of the constant shifting of workers, and an investigation of the methods pursued in compiling these data proved them to be mere guesswork. Attention was directed to them by the exaggerated totals for the city of Cleveland which was reported to have 75,000 unemployed, one-fourth of that reported for the United States. In attempting to explain how these figures were compiled it was evident that those in charge made them up by-guess and by-gosh. It was pointed out to the responsible heads of the service that either the totals for the city of Cleveland were grossly exaggerated or the returns for the country were wrong. Was any attempt made to correct these figures? It was not—decidedly not. Would they recede from their autocratic position or attempt to correct the wrong impression conveyed? They would not. But congress held the whip hand. Without money even these bureaucrats lose interest in their work. Henceforth these unemployment figures will not be available. Congress cut off this service without even sufficient funds to carry it through to the end of the present fiscal year. The purpose of this service was well conceived. It had a mission to perform, but its efforts were misdirected. The purpose of these exaggerated unemployment figures is not yet clear. Surely it could not have been done to breed a spirit of unrest with the prevailing order of things. Let's be charitable and give them the benefit of the doubt. But congress did a good job.

Trade Outlook in the Foundry Industry

A STEADY gain in activity is reported by practically all branches of the foundry industry. None has returned to a normal basis, nor could this be expected after so complete a turn-over of industry as that following the cessation of hostilities early in November. The steel casting trade which was on a 90 per cent war basis has suffered most. Some of these plants, following the cancellation of government contracts, were confronted with barren order books and it is from this condition that they have been slowly emerging. Reductions in prices have been made that have attracted some tonnage, but the industry as a whole is operating far below capacity, although inquiry during the last 30 days has been heavier than at any time in the last four months.

Increase In Malleable

Malleable iron plants, on the other hand, are operating at about 70 per cent of capacity. This represents a large increase in volume since the first of the year and reflects, in part, the resumption of pleasure car manufacture. A limited amount of railroad work is represented in the tonnage on the books of the malleable iron producers, but large orders from the agricultural implement trade are conspicuous by their absence. However, the outlook is considered exceedingly favorable for the early resumption of the malleable shops at capacity. Price reductions have been made, although it is doubtful if further concessions will be forthcoming in view of high labor and raw material costs. As compared with conditions that prevailed last year, the situation is encouraging and foreshadows an increase in output over 1918.

Changes in Pig Iron Prices Sept. 24, 1917, to March 21, 1919

Pig iron grade	Silicon, per cent	Sept. 24, 1917 to Sept. 30, 1918	Oct. 1, 1918 to Dec. 31, 1918	Jan. 1, 1919 to Mar. 21, 1919	Mar. 21, 1919 to remainder of year	Reduction per ton since Jan. 1, '19
No. 2 Foundry (base)	1.75 to 2.25	$33.00	$34.00	$31.00	$26.75	$4.25
No. 2X Foundry	2.25 to 2.75	33.50	35.25	32.25	28.00	4.25
No. 1 Foundry	2.75 to 3.25	34.50	37.00	34.00	29.75	4.25
No. 1X Foundry	3.25 to 3.75	35.50	39.00	36.00	31.75	4.25
Malleable	Up to 2.25	33.50	34.50	31.50	27.25	4.25
Malleable	2.25 to 2.75	33.50	35.25	32.25	28.00	4.25
Malleable	2.75 to 3.00	33.50	37.00	34.00	29.75	4.25
Basic	.....	32.00	33.00	30.00	25.75	4.25
Bessemer	.....	35.20	35.20	32.20	27.95	4.25

Gray Iron Operations

It is difficult to summarize the condition of the gray iron industry because of the many cross-currents that affect trade conditions. Considered from the standpoint of number of foundries engaged, the jobbing branch of the trade is the predominating factor. A general curtailment of industrial activity affects this branch adversely and is now suffering from the general halt in operations arising from the readjustment from a war to a peace basis. Many of the larger jobbing shops, however, report a marked improvement in orders and their melt is steadily increasing. Among the specialty shops, those engaged in automobile work are being crowded for deliveries and the indications are that this condition will prevail throughout the first half of the year. Many plants also are engaged in the manufacture of engine castings for our great merchant fleet and operations here are being crowded with almost the same zeal as prevailed throughout the war period. The same condition applies to casting production for the navy and the tonnage involved is no small factor in the total output of the gray iron plants. Foundries specializing in castings for the machine tool trade report a limited demand and an increase in volume is not anticipated until the large stock of machine tools in the hands of the government and builders has been absorbed.

Pig Iron Reduced

Reductions in pig iron prices, effective March 21, are of little interest to foundrymen. Practically the entire pig metal needs of the casting manufacturers, for the first six months of this year, were contracted for during the last half of 1918 at prices of $33 to $34 a ton for No. 2, and the furnace operators have refused to make concessions to the $31 level established on Jan. 1 and to the $26.75 basis in effect today. In announcing the recently agreed prices it was stated specifically that these are not to be retroactive. This same condition applies to steel prices, although it is known that since the first of the year, contracts for steel have been made which protect the buyer against decline. Reports have been prevalent that many consumers of pig iron are refusing to accept their monthly allotments, but the shipments from the furnaces do not bear this out. Almost the entire iron output is being delivered and accepted and no stocks are being accumulated in furnace yards. However, on all new business, the prices announced on March 21 will apply and are as follows: No. 2 foundry, base, $26.75; malleable up to 2.25 silicon, $27.25; basic, $25.75, and bessemer, $27.95. Accompanying is a comparative table of prices.

To Promote Prosperity

In announcing the results of the conference with the industrial board of the department of commerce, Judge E. H. Gary, chairman of the board of the United States Steel Corp. made a statement from which the following is quoted, in part:

> The objects to be secured are a revival and stabilization of business by establishing a reasonably low basis of prices which would be satisfactory to the consuming public and so far as practicable would yield a moderate and reasonable return to the investors where they are entitled to it in the application of sound business principles; and at the same time, would not disturb wage rates or interfere with wage agreements; and, further, having determined upon prices which it is expected will not be reduced during this year, it is believed that the volume of business will be promptly increased and that furnaces and mills will be operating at a larger increased capacity, thus giving employment to a correspondingly increased number of employes.

Brass and aluminum foundry operations are below normal, although the activity of the automobile trade has brought a large volume of business to these plants. Casting copper is quoted at $14.75c to 14.87½c, New York; lead, 5.25c; tin, 72.50c; spelter, 6.20c; antimony, 6.50c to 6.62½c and aluminum, No. 12 alloy, 33c, producers' price and 26c, open market.

COMINGS AND GOINGS OF FOUNDRYMEN

Miss Inez Saverly has been appointed purchasing agent for the Holt Mfg. Co., Peoria, Ill., to succeed H. Huffstadter.

A. S. Blagden has been elected president of the Air Reduction Sales Co., 120 Broadway, New York.

H. W. Doennecke has been appointed metallurgist for the Mineral Point Zinc Co., Depue, Ill.

John J. Davison has been appointed superintendent of the foundry operated by the Downington Mfg. Co., Downingtown, Pa.

Clarence W. Andrews has been employed as a chemist in the openhearth department of the American Steel Foundries, Alliance, O.

J. K. Haigh has been appointed assistant district manager of sales of the San Francisco office of the Chicago Pneumatic Tool Co., Chicago.

E. R. Swanson, recently discharged from the service, has been made works manager of the Duquesne Steel Foundry Co., Corapolis, Pa.

W. W. Zeman, sales engineer affiliated with the Cleveland Osborn Mfg. Co., Cleveland, has returned from France where he was on the fighting front for a period of eight months.

W. A. Smith, formerly general superintendent of the Acme Harvesting Machine Co., Peoria, Ill., has been appointed to a similar position with the Maytag Co., Newton, Iowa.

V. L. Criner, formerly assistant superintendent of the Acme Harvesting Machine Co., Peoria, Ill., has been appointed assistant machine shop foreman of the Avery Co., Peoria.

Ross G. Hinman, recently discharged from the army, has been employed in the testing department of the New Jersey Zinc Co., New York.

H. A. Jackson, president of the Chicago Pneumatic Tool Co., Chicago, has returned from England, where he made an inspection of the foreign plants of his company.

W. M. McIntyre, formerly sales manager of the Sharon Foundry Co., Sharon, Pa., has resigned to organize a company which will build and operate a new steel foundry.

Walter J. Canfield has been appointed superintendent of grinding, polishing, buffing and lacquering at the plant of the American Ever-Ready Works, Long Island City, N. Y.

E. C. B. Gould, lieutenant-commander, naval aviation corps, has received his discharge and has accepted a position in the sales force of the Pittsburgh Iron & Steel Foundries, Pittsburgh.

F. W. Sebelin, formerly master mechanic at the plant of the National Malleable Castings Co., Cleveland, has accepted a position as plant engineer for the Ferro Machine & Foundry Co., of the same city.

Thomas E. Monk, president of the Cleveland National bank, Cleveland, has been elected president of the Carroll Foundry & Machinery Co., Bucyrus, O., manufacturer of locomotive cranes.

C. W. Johnson, who for the past 10 years has been general superintendent of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has been appointed assistant manager of works.

James W. Armour, secretary of Armour's Pattern Shop Co., Worcester, Mass., has been promoted from lieutenant to captain in the ordnance department. Mr. Armour is in charge of a mobile repair shop in France.

Edward R. Sutton, who has represented the Buckeye Products Co., Cincinnati, in a sales capacity in New England, now is affiliated with Frederic B. Stevens, Detroit, with headquarters at New Haven, Conn.

H. C. Alleman, formerly of the sales force of the Lewis Foundry & Machine Co., Pittsburgh, now is affiliated in a sales capacity with the Pittsburgh Iron & Steel Foundries Co., Pittsburgh.

Thomas W. Pangborn, president and treasurer of the Pangborn Corp., Hagerstown, Md., has been appointed a member of the Maryland readjustment committee to represent the western part of that state for the purpose of re-establishing normal business conditions.

A. D. Dancey has been appointed general superintendent of the Acme Harvesting Machine Co., Peoria, Ill., to succeed W. A. Smith who recently resigned. H. B. Sour has been appointed assistant to Mr. Dancey and A. W. Bybee purchasing agent.

R. J. Wean, formerly of the Aetna Foundry & Machine Co., Warren, O., has become affiliated with the Columbiana Foundry Co., Columbiana, O. He will have charge of the commercial interest of the company in the Ohio valley district.

Lieut. J. Sullivan, who recently returned from overseas duties with the American Expeditionary forces in France, has received an honorable discharge and has resumed his position as vice president of the Columbiana Foundry Co., Columbiana, O.

Elmer D. Pellegrin, formerly production manager of the Evansville, Ind., works of the Bucyrus Co., South Milwaukee, Wis., has been appointed general production manager in charge of both plants of the company. His office will be in South Milwaukee.

H. D. Gates, advertising manager of the Pangborn Corp., Hagerstown, Md., will deliver an illustrated address on sand-blast equipment and its operation, at a meeting of the Newark Foundrymen's association, Newark, N. J., on April 2.

Harold E. Taylor, Cranston, R. I., has accepted a position with the Aluminum Castings Co., Cleveland, where he will collect and report the results of metallurgical experiments made for the company by its chemical department.

J. E. Webster, director of buildings and equipment, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., addressed the Pittsburgh Foundrymen's association on March 17, on the subject of interworks transportation.

Willis B. Clemmitt, formerly assistant superintendent of the openhearth department of the Central Iron & Steel Co., Harrisburg, Pa., has been made advisory engineer for the Powdered Coal Engineering & Equipment Co., Chicago.

Andrew Barr has been appointed superintendent of the Waterloo Gasoline Engine Co., Waterloo, Iowa. Mr. Barr was associated with the United States Wind Engine & Pump Co., Batavia, Ill., from 1894 until his resignation last month.

J. H. Casebeer, for the last five years supply agent of the American Steel Foundries, Sharon, Pa., has resigned and will go into business for himself in Indiana. His successor has not been appointed and probably will not be until the plant is ready to resume.

Malcolm E. Maclean, formerly with the American Steel Foundries, Chicago, and until recently a major of infantry in the army, has received his discharge from the service and has become sales manager of the Duquesne Steel Foundry Co., Pittsburgh.

Major R. A. Bull, vice president of the Duquesne Steel Foundry Co., Pittsburgh, who served in the ord-

nance department during the American participation in the war, has received an honorable discharge and has resumed his former duties with the Duquesne Steel Foundry Co.

Fred H. Waldron, formerly Minneapolis representative of the Chicago Pneumatic Tool Co., Chicago, has been appointed manager of the pneumatic tools sales division of this company, succeeding J. G. Osgood, resigned. Mr. Waldron has been succeeded at Minneapolis by Nelson B. Gatch.

Walter J. Adams, for many years engaged in the foundry supply business and one of the veterans of this industry, now is affiliated in a sales capacity with the S. Obermayer Co., Chicago. Mr. Adams formerly was associated with the Federal Supply Co., Cleveland, of which he was president.

Edward S. Davis, affiliated with Tate-Jones & Co., Inc., Pittsburgh, has resigned as chief of the fuel oil section of the bureau of oil conservation of the United States fuel administration, and will serve as Chicago district manager of Tate-Jones & Co., with offices in the Monadnock building.

W. C. Smith has been made superintendent, and John Kelly, assistant superintendent, of the Ironton Malleable Iron Co., Ironton, O. Both were formerly connected with Danville Malleable Iron Co., Danville, Ill., and accompanied C. D. Townsend who recently was elected general manager of the Ironton company.

G. Walter Esau, president, Modern Steel Foundry Co., Milwaukee, was elected president of the Milwaukee chapter, American Steel Treaters' society, at its recent annual meeting. Charles J. Wesley, secretary-treasurer, Wesley Steel Treating Co., was elected secretary-treasurer of the chapter.

George H. Ruppert, recently resigned from the chemical warfare branch of the service, has been made an advisory engineer with the Powdered Coal Engineering & Equipment Co., Chicago. Before entering the service, Mr. Ruppert had charge of the sodium-ferrocyanide department of the Semet-Solvay Co.

Staunton B. Peck, acting president of the Link Belt Co., Philadelphia, and R. S. Dyson, in charge of special machinery drives for the same company, addressed the monthly meeting of the New England Foundrymen's association held in Boston on March 12. The papers presented discussed the economical handling of foundry materials.

W. H. Fitzpatrick Jr., who has been affiliated with the S. Obermayer Co., Chicago, for many years, having been located both in Pittsburgh and at Syracuse, N. Y., has been appointed eastern sales manager for Frederic B. Stevens, Detroit, with headquarters at New Haven, Conn. Frederic B. Stevens, manufacturer of foundry facings and supplies, buffing compositions and platers' supplies and equipment, will carry a stock of material at New Haven.

Alonzo G. Davis has been elected president of the Arcade Malleable Iron Co., Worcester, Mass., succeeding the late H. Paul Buckingham. Thomas T. Booth, who succeeds Mr. Davis as treasurer of the company, has been purchasing agent for Crompton & Knowles Loom Works and has been interested in the Standard Foundry Co., both Worcester corporations. Mr. Booth also is interested

LEON E. THOMAS

in the Philbrick-Booth Foundry Co., Hartford, Conn.

W. V. Couchman, general sales manager of the International Harvester Co., has been appointed vice president in charge of all foreign business, with headquarters in Europe, to have charge of rehabilitation of the company's European connections. Alexander Legge, general manager since 1913, has been made vice president and director. The company has also elected Herbert F. Perkins, A. E. McKinstry and H. B. Utley vice presidents.

Robert J. Anderson has resigned as research metallurgist with the bureau of aircraft production, Detroit, to join the staff of the bureau of mines, experiment station, Pittsburgh, for the purpose of making special investigations in the metallurgy of aluminum and other nonferrous metals with special reference to melting practice. Prior to his connection with the bureau of aircraft production during the war, he was metallurgist for the Cleveland Metal Products Co., Cleveland, and previous to that time was a member of the staff of *The Iron Trade Review.*

Accepts New Position

Leon E. Thomas has resigned as vice president and general manager of the Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., to become president of the Reading Iron Co., Reading, Pa., manufacturer of pipe. John E. McCauley, who has been assistant general manager, succeeds Mr. Thomas as vice president and general manager of the Birdsboro Co. F. C. Smink, whom Mr. Thomas succeeds as president of the Reading Iron Works, has been elected chairman of the board of directors of that company.

Mr. Thomas has been prominently identified with the iron and steel industry since he graduated from Pennsylvania State college in 1898. He was associated for a short time with the Mackintosh, Hemphill Co., Pittsburgh, and left that company to enter the engineering department of the Ohio Steel Co. shortly before the latter became a part of the United States Steel Corp. During his connection with the corporation he was assistant master mechanic in charge of constructing the first two blast furnaces built at the Youngtown, O., plant.

In 1902 Mr. Thomas left the steel corporation to become superintendent of the Youngstown plant of the United Engineering & Foundry Co. Later he was transferred to the Pittsburgh office of this company and while holding this position he also acted as consulting engineer for the Republic Iron & Steel Co. in the construction of its rail and sheet bar mill at Youngstown.

In 1905 Mr. Thomas accepted the position of general manager for the Birdsboro Steel Foundry & Machine Co., and in 1918 he was made vice president and general manager. Mr. Thomas was prominent in various industrial activities connected with the successful promotion of the war. Among other services, he acted as chairman of the war service committee of the Steel Founders' Society of America.

Engineering Advertisers Association Organized

Advertising and sales managers representing manufacturers in various engineering lines in the Chicago district have organized the Engineering Advertisers' association. This society will be dominated by its active membership although the by-laws provide that associate members may be admitted, including publishers and their representatives, solicitors and service

agency men whose interests are confined to engineering projects. Active membership, however, is limited to those in responsible charge of advertising or sales of the companies with which they are identified. Meetings will be held monthly, except during July and August and speakers of recognized prominence in the field of engineering advertising will deliver addresses on subjects of general and special interest to the members at their various meetings.

Officers have been elected as follows: President, H. L. Delander, advertising manager, Crane Co.; vice president, H. Colin Campbell, director of advertising, Portland Cement association; secretary, G. H. Eddy, publicity manager, Green Engineering Co., East Chicago, Ind., and treasurer, Edward J. Pratt, advertising manager, Kellogg Switchboard & Supply Co.

The board of directors is constituted as follows: For one year, G. S. Hamilton, advertising manager, American Steam Conveyor Corp.; J. J. Arnsfield, advertising manager, Fairbanks, Morse & Co., and A. P. Hauck, director of advertising, Allis-Chalmers Mfg. Co., Milwaukee. For two years: H. W. Clarke, advertising manager, Chicago Pneumatic Tool Co.; P. A. Powers, advertising manager, Benjamin Electric Mfg. Co., and J. C. Kinsley, secretary, A. M. Davis Regulator Co.

The following membership committee also has been appointed: Albert H. Hopkins, advertising manager, C. F. Pease Co.; H. W. Stannard, president, Twin Fire Furnace Co., and W. L. Schultz, sales manager, James A. Brady Foundry Co.

Cast Steel Car Casting Prices Reduced

The United States railroad administration has announced the revision of the prices recommended by the American Iron and Steel institute on bolsters, side frames and cast steel car castings entering into the construction of the 100,000 freight cars ordered by the administration nearly a year ago and on the side frames for 1300 of the 2030 locomotives being built for the transportation lines under federal control. The revision represents a 4 per cent reduction from the institute's schedules in effect the last quarter of 1918 and, it is estimated, represents a reduction to the railroads by the steel casting manufacturers of approximately $1,000,000 on these contracts. It is understood the new prices will not apply to maintenance orders for these castings nor to any future equipment contracts except as the foundries agree to accept them. The revised prices continue as gross sales quotations.

The journal box and coupler castings prices suggested by the institute were reviewed, but were not revised, while the brakebeam and miscellaneous malleable iron prices were not taken under consideration. The steel castings prices as revised apply to cars of the four capacities of standard type, 40, 50, 55 and 70 ton. The 55-ton type car castings were not provided for in the institute's schedules and the administration accepted the 57½-ton quotations as a basis. The reason only 1300 of the locomotives are affected by the side frame price revision is that this number was ordered from the American Locomotive Co. with the specialties being bought direct by the administration. In the other locomotives, ordered from the Baldwin Locomotive Works and the Lima Locomotive Works, Inc., the parts were contracted for by the builders. The accompanying tables show how the 4 per cent reduction applies to the schedules of the institute.

Revised Steel Casting Prices

BOLSTERS, BODY OR TRUCK

Car capacity, tons	Quoted price	Reduction	Revised price
30	$87.50	$3.50	$84.00
40	99.50	3.98	95.52
50	108.50	4.34	104.16
57½	118.50	4.74	113.76
62½	130.00	5.20	124.80
70	165.50	6.62	158.88

TRUCK SIDE FRAMES FOR FREIGHT CARS AND LOCOMOTIVE TENDERS

Car capacity, tons	400 and over, per car Quoted price. A*	P†	Revised price A*	P†
30	$118.50	$124.50	$113.76	$119.52
40	129.50	135.50	124.32	130.08
50	139.50	151.50	133.92	145.44
57½	154.50	166.50	148.32	159.84
62½	170.00	181.00	163.20	173.76
70	175.50	201.50	168.48	193.44

*Andrews design.
†Pedestal design.

Uncle Sam is the World's Greatest Merchant

To the Editor:

Referring to my communication entitled "Uncle Sam—Storekeeper," published in your March, 1919, issue, I noticed a special dispatch from Washington in one of the daily papers stating that the government now has on hand 140,000,000 pounds of surplus copper which is to be sold at 15 cents per pound. If this be true—and I have no reason to doubt it—I fear the government stands to lose millions of dollars on the resale of this one item.

Since my communication was printed in THE FOUNDRY I have seen the war department's published list of stocks of clothing and textiles in the United States, overseas and in transit, on Feb. 1, 1919, from which it appears that the value of manufactured clothing on hand is $590,086,652. The value of unmanufactured textiles is $128,127,005. The value of bed sacks, bags and tents is $30,647,331 making a total of nearly $750,000,000.

A few of the items are as follows:

Shoes	$82,830,466
Rubber boots	12,351,692
Trousers and breeches	80,585,969
Coats	73,334,232
Overcoats	34,064,378
Undershirts	54,257,481
Stockings	26,940,299
Drawers	52,740,830

When the complete lists of all surplus goods including foodstuffs, etc., now in Uncle Sam's storehouses awaiting disposition shall have become available, the public will I think, be treated to some sensational surprises at their vastness, as well as amazement at the prices paid in many cases.

Profiteers who sold hundreds and hundreds of millions of dollars of goods, often at inflated figures, may now have the opportunity to repurchase many of their own manufactured products at bargain prices.

The chief of the "Surplus Property Division," L. H. Hartman, recently said that many manufacturers and wholesalers had suggested that owing to the present situation, it would be well for the government to hold goods for a year or two and refrain from making efforts at disposal other than to other governmental departments, but that this was not possible because storage space is costing big money and while the government wishes to proceed with the greatest care, it is not possible to merely hold the merchandise.

It is said that sales may be made by three methods:

First.—By negotiation, where such sales are possible at ruling market prices.
Second.—By sealed proposals.
Third.—By public auction.

It appears from the foregoing that our Uncle Sam is not only the greatest storekeeper today, but he is preparing to become the greatest auctioneer in the world, and the probability is that his largest customers for the big bargaining in prospect will be those manufacturers and merchants who piled up vast fortunes while patriotically doing *war work* and furnishing Uncle Sam with goods at wonderful prices.

Assuming that our Uncle Sam may possibly realize an average of 50 per cent of original cost of the vast stocks of surplus goods which he now has to sell, the actual loss will nevertheless mount up to hundreds of millions of dollars, without counting huge costs of handling, storage, etc.

In the final analysis this loss falls upon the people and liquidation may extend over a period of several years;

the prospect of long continuation of high taxes, growing out of war expenses amounts to a certainty, even though the *league of nations*, or some higher power, may happily preserve us from all wars in the future, or at least for a generation to come.

Alex. E. Outerbridge Jr.

Portable, Rock-Over Molding Machine

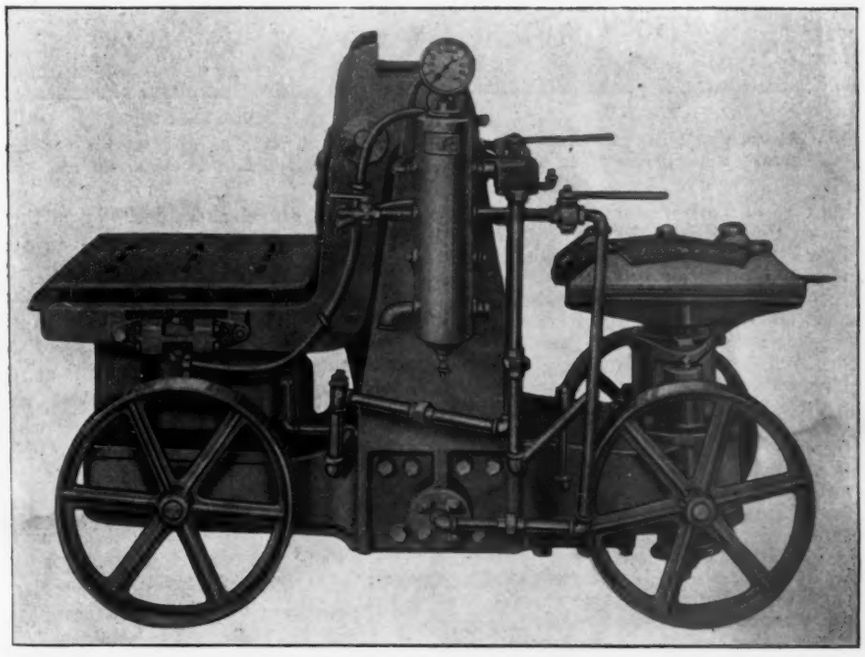
In the accompanying illustration is shown a portable, jolt-ramming rock-over machine built by the Davenport Machine & Foundry Co., Davenport, Iowa. This machine is similar to the stationary rock-over machine built by this company except that it has been made portable by mounting it on four wheels. It jolts the molds, rolls them over and these are then dropped away from the pattern plate for drawing the pattern. It has a pattern draw of 10 inches and the jolt table is 18 inches square. The pattern plate is 20 x 26 inches, and flasks up to 20 x 34 inches and 12 inches deep can be accommodated. The rated capacity of the machine is 750 pounds.

Centering Gage for Patternshops

The Syracuse Sander Mfg. Co., Syracuse, N. Y., maker of disk and oscillating spindle grinders, has produced a precision centering gage for pattern shop use. In this instrument a vertical post, set into the base, carries an arm which may be raised or lowered as desired. On the arm, and moving in a line perpendicular to the center point of the base is a sharp-pointed scribe or stylus held by a set screw. In transferring a center-point, the pattern is set with its center on the pin in the base. The arm then is lowered and the point of the stylus pressed into the pattern, marking the projection of the center upon the upper surface. The stylus may be removed and placed horizontally for use as a surface gage if desired. The instrument is shown in the accompanying illustration.

CORE OVENS INSTALLED BY THE OHIO BLOWER CO., CLEVELAND, AT THE PLANT OF THE ALLYNE-RYAN FOUNDRY CO.

NEW PRECISION GAGE FOR TRANSFERRING CENTERS ON PATTERNS



DAVENPORT PORTABLE JOLT-RAMMING ROCK-OVER MACHINE

Fire Fails to Halt Production

When fire recently destroyed one of the core rooms of the Allyne-Ryan Foundry Co., Cleveland, production was not seriously retarded. When the debris was cleared away, it was found that the core oven equipment installed by the Ohio Blower Co., Cleveland, was intact and ready for use and was unaffected by the streams of water which had played on the steel plates of which it is constructed and was uninjured by the heavy impact of the falling beams and trusses. The delicate cores for automobile cylinder castings which were in the ovens throughout the fire were found to be dry and perfectly baked and were ready for assembling. The oven burners were lighted following the fire and the ovens standing in the open, surrounded by the charred wreckage, were used to maintain constant production. These ovens are shown in the accompanying illustration. The work of rebuilding the core room is under way upon the site of the one destroyed by fire, and insofar as corebaking facilities are concerned, the output has not been hampered.

Establishes St. Louis Office

The Marden, Orth & Hastings Corp., New York, manufacturer of core binders, has established an office in the Syndicate Trust building, St. Louis, in charge of David Lewis and Carl Schnabel.

The Advance Foundry Co., Dayton, O., has removed its offices to its new plant located at Parnell and Florence avenues in the same city.

Practical Instruction Card for Crane Signaling and Operation

Simple instructions are imperative where they concern machines which possess elements of danger to the operator or fellow workmen. To meet the need of crane operation, the Cleveland Crane & Engineering Co., Wickliffe, O., has devised a simple card, containing general instructions, illustrations of crane signals and data on the care of cranes. This card is mounted on a special board with a glazed surface, which is designed to resist deterioration under shop atmosphere. It is the intention that these instruction signs shall be placed upon the crane and also in various points about the shop floor for the information of the workmen.

The signals recommended are those adopted by the National Society Council. These are shown in the illustration accompanying. The instructions given are as follows:

Before throwing in main switch for starting crane, be sure no one is working on it.

Do not take signals from more than one man at a time.

Report any crane trouble to crane inspector.

Do not carry load over men working on floor.

Keep close watch of man making hitch.

Do not plug motor by reversing controller. Use brake.

Do not apply foot brake too suddenly. Flat spots on wheels will result when crane skids.

Do not leave controller arm set between contacts.

Do not operate controller to end, suddenly. Give motor time to accelerate.

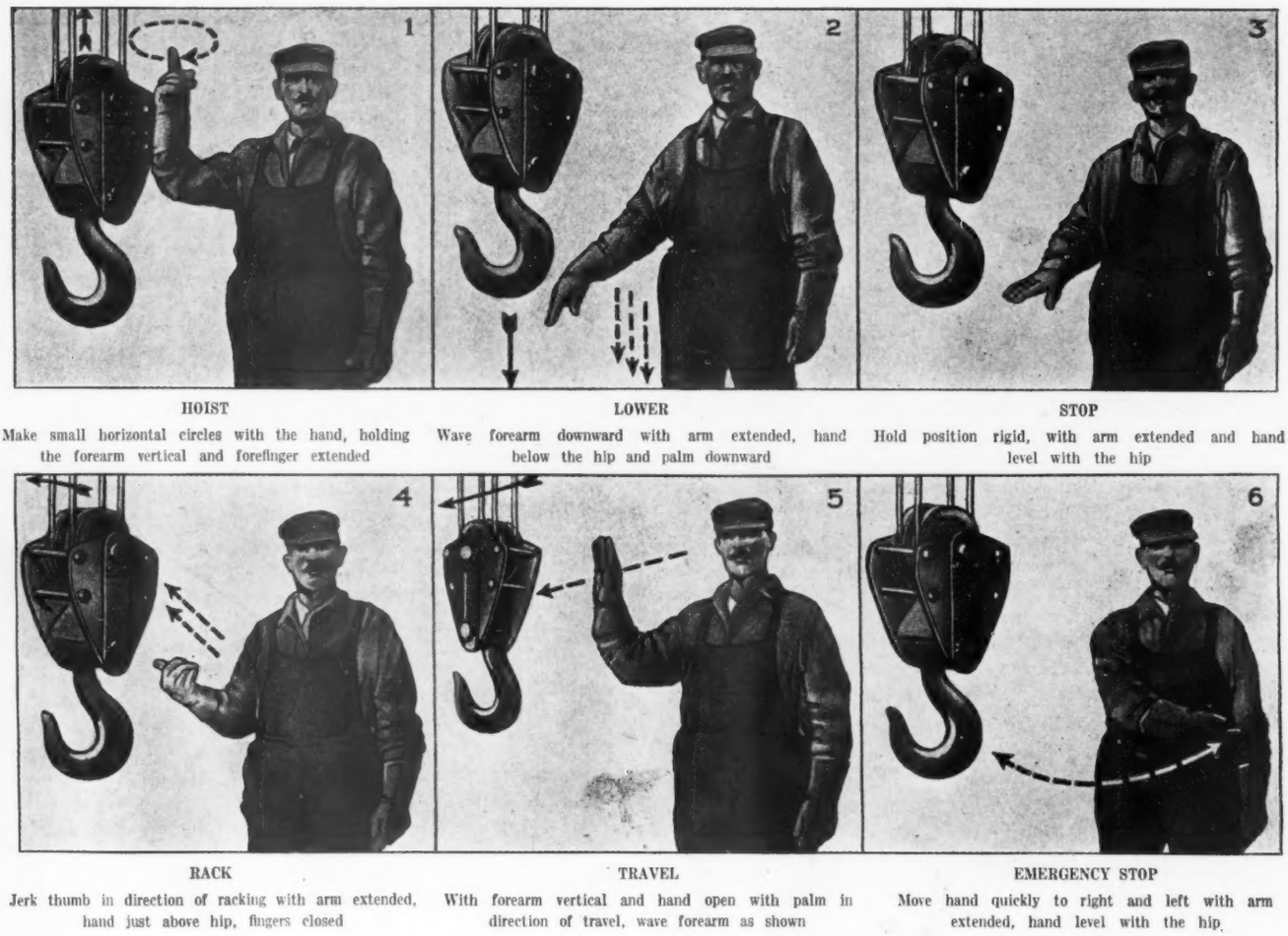
Do not forget to pull main switch when leaving cage.

Care of Cranes

Regular inspection.

Routine inspection: Grease cups given a turn or more each day. Note that oil in all motor bearings is not more than ⅛-inch below top of overflow. Work the electric brake several times, noting its condition as to adjustment and wear of shoe lining. In addition the foregoing, every four weeks, open the motors and see that brushes are not stuck, but have free movement and are not worn too short. Blow out motors with bellows, drain out old oil and replace with fresh. Note that all wiring connections are secure. Open controllers, noting conditions of fingers and segments applying fresh vaseline to same.

Operate limit switch several times to be assured of its condition. Keep cage and crane clean, be careful that no wrenches or other materials are left on crane where it will jar off and injure workmen on the floor below.



1 — HOIST
Make small horizontal circles with the hand, holding the forearm vertical and forefinger extended

2 — LOWER
Wave forearm downward with arm extended, hand below the hip and palm downward

3 — STOP
Hold position rigid, with arm extended and hand level with the hip

4 — RACK
Jerk thumb in direction of racking with arm extended, hand just above hip, fingers closed

5 — TRAVEL
With forearm vertical and hand open with palm in direction of travel, wave forearm as shown

6 — EMERGENCY STOP
Move hand quickly to right and left with arm extended, hand level with the hip

Opens New Sand Plant

Production is under way at the new sand and gravel plant of the Eau Claire Sand & Gravel Co., Eau Claire, Wis. With over 100 acres of land on which is a 48-foot bank of red flint sand, this company has installed equipment and is producing over 500 tons per day of sand-blast sand and gravel.

The material is taken from the banks by a crane with a 30-foot boom, handling a 1½-yard bucket, and is dropped into a hopper. From this, the sand is carried to the top of a series of bins on a 20-inch conveyor belt. At the top of the bins are two screens which separate the sand, gravel and stone. From these, the sand is carried by gravity in steel chutes to six classifiers, built by the Allis-Chalmers Mfg. Co., Milwaukee. These wash the sand and divide it into three grades which will pass 20, 30 or 40-mesh screens. The spouts from the classifiers deposit the sand in bins, each equipped with a hinged steel chute which allows the material to drop to cars.

The hoisting and conveying equipment, exclusive of the crane, is driven electrically. A motor-driven pump furnishes 750 gallons of water per minute for washing the gravel and sand. The officers of the company are F. E. Nicholes, president; C. L. Tolles, vice president, and George W. Robertson, secretary.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Canadian Iron Corp., Fort William, Ont., plans to remodel its pipe foundry.

The Sawyer Brass & Iron Foundry, Oswego, N. Y., plans to build a foundry addition, 65 x 165 feet.

The Connecticut Foundry Co., Rocky Hill, Conn., is planning the erection of a foundry, 100 x 160 feet.

The Central Foundry Co., Saginaw, Mich., has started work on the erection of its new plant.

J. Maggs, 1611 Eighth avenue, Seattle, is contemplating the erection of a foundry.

The Hay Foundry & Iron Works, Plum Point Lane, Newark, N. J., plans alterations to its plant.

The Iron City Foundry Co., Hamilton, O., plans the erection of a foundry addition.

The H. A. Frank Foundry & Machine Co., Moline, Ill., plans the erection of an addition, 60 x 80 feet.

An addition to the foundry of the Portage Iron Works, Portage, Wis., will be erected shortly. A. R. Slinger heads the company.

A foundry building will be erected by the Brisk Blast Co., Monroe, Mich. Plans now are being drawn. A. F. Meyers is superintendent.

The construction of a foundry is being planned by Hutchinson Bros. & Co., Ltd., Victoria, B. C.

Construction will be started soon on a foundry and machine shop for the United Iron & Machine Co., Ltd., Haileybury, Ont. A. B. Ullhorn is engineer.

The Hub City Iron Works, 228 First avenue, Aberdeen, S. Dak., A. T. Green, president, has closed bids for the construction of a foundry addition.

The Wilmington Casting Co., Wilmington, O., E. R. Bales, president, is making preliminary estimates for the erection of a foundry, 28 x 115 feet.

Fred Servei recently purchased a plant site at Marine City, Mich., from S. C. McLouth, and plans the erection of a foundry, 50 x 100 feet.

The carpenter and pattern shops of the Carnegie Steel Co., Farrell, Pa., recently were badly damaged by fire. The loss has been estimated at $100,000.

The Romeo Foundry Co., Port Huron, Mich., is reported planning to construct a foundry at Sarnia, Ont. L. G. Blunt is manager.

The Globe Foundry & Machine Co., Globe, Ariz., plans to erect an addition to its plant on South Broad street.

The Anderson Foundry & Machine Co., Anderson, Ind., has been incorporated with $1,200,000 capital, by W. N. Durbin, D. H. Durbin and M. B. Sibel.

Clyde Dannals, Albany, Oreg., plans to construct a blacksmith shop and foundry, 40 x 45 feet. New equipment will be needed.

The National Beet Harvester Co., Brighton, Colo., is planning the erection of a plant which will include a foundry.

The Wilson Foundry & Machine Co., Pontiac, Mich., C. B. Wilson, president, contemplates the erection of an addition to its plant, 100 x 800 feet.

Fire recently damaged the pattern shops of the Pencoyd Iron Works, Pencoyd, Pa. The loss was estimated at $60,000.

Plans are being prepared for the construction of a foundry and machine shop, 70 x 300 feet, for the James Mfg. Co., Ft. Atkinson, Wis.

The Mainland Engineering Co., Vancouver, B. C., contemplates the erection of a plant on George street, which will include a foundry.

Thomas Pink, Ltd., Pembroke, Ont., has been incorporated with $200,000 capital, to do business as a founder, blacksmith and machinist. The incorporators are Thomas Pink, Edward A. Dunlop and William L. Hunter.

The plant of the Russell Foundry & Machine Works, 67-73 Sixth street, Long Island City, N. Y., recently was badly damaged by fire.

The B. & C. Machine & Foundry Co., Tulsa, Okla., has been incorporated with $100,000 capital, by W. P. Cunningham, V. L. Hudson and B. C. Connor.

Bids have closed for the construction of a foundry, 60 x 100 feet, for the H. & H. Foundry Co., Stamford, Conn.

The F. H. Linthicum Bronze Foundry, 325 East Oliver street, Baltimore, is reported considering the construction of a plant addition.

The erection of a new foundry is being planned by the Bridge & Beach Mfg. Co., 503 South First street, St. Louis.

The Eastern Metal Products Co., Portland, Me., has been incorporated with $25,000 capital, to operate a foundry, machine shop, etc.

The firm name of the Advance Machine Co., Los Angeles, Cal., manufacturer of cast iron fittings, has been changed to the Los Angeles Valve & Fittings Co.

The Wellston Mfg. Co., Wellston, O., recently took over the Eclipse foundry. The capitalization of the company is $100,000.

Bids have been taken by the Watson-Frye Co., Bath, Me., for the erection of a foundry and factory building. The company was recently incorporated.

The Defiance Machine Works, Defiance, O., is reported to be contemplating the construction of a foundry.

The Root & Van Dervoort Engineering Co., East Moline, Ill., has acquired 61 acres as a future site for shop and foundry buildings.

J. B. Mant, Portland, Oreg., is reported planning the construction of an iron foundry at Nampa, Idaho. A. W. Hoy, of the Nampa Commercial club is placing the contracts.

The plant of the Superior Mfg. Co., Bessemer, Ala., former manufacturer of cast iron pipe, has been purchased by Charles A. Hamilton of the Alabama Pipe & Foundry Co., Anniston, Ala.

The Delta Foundry & Machine Corp., New York, has been incorporated with $250,000 capital, by F. C. Reilly, F. J. McCaul and J. F. Shea, 110 Fifty-seventh street, Brooklyn.

Correspondence for the Nickel Plate Foundry Co., a recent Ohio incorporation, is being received at 948 Engineers building, Cleveland. The company has not yet completed its plans.

The Sivyer Steel Casting Co., Milwaukee, recently acquired five lots adjoining its plant, which will be utilized for future extensions. No definite plans have been made.

The Holmes Foundry Co., Port Huron, Mich., Senator Lyman A. Holmes, president, is reported planning to double the capacity of its plant. The company's South Park plant recently was damaged by fire.

Hunt-Helm-Ferris & Co., Harvard, Ill., manufacturers of farming implements, are having plans prepared for the construction of a foundry, 50 x 250 feet.

The March Brownback Stove Co., Charlotte & South streets, Pottstown, Pa., has let a contract to Frederick H. Keiser & Co., 128 East Fourth street, for the construction of a foundry addition, 60 x 60 feet. Frank Sevinson and John Healy are in charge.

The Deline Engineering Co., Brooklyn, N. Y., has been incorporated to manufacture foundry and factory supplies, with $50,000 capital, by S. V. Coles, E. H. and O. A. Deline, 171 Clymer street.

Plans have been completed for enlarging the plant of the Durbin Foundry, Terminal Belt and Bond avenues, East St. Louis, Ill. V. S. Durbin is president of the company.

The B. Hoffman Mfg. Co., 257 Sixth street, Milwaukee, which operates a foundry and machine shop, plans the construction of a building to replace one recently damaged by fire.

The Canadian Foundry & Machine Co., 47 Sterling road, Toronto, Ont., is having plans prepared by Ellis & Ellis, Manning Chambers, Queen street west, for the construction of a plant addition.

The Newark Stamping & Foundry Co., Newark, O., has purchased the equipment of the May, Fieberger Co., Akron, and extensions to the company's plant to accommodate the equipment will be made.

The Ferro Machine & Foundry Co., East Sixty-sixth street and Hubbard avenue, has a permit to erect a foundry addition, 18 x 60 feet. The contract has been let to the A. A. Lane Construction Co.

Contracts for the construction of a molding floor and auxiliary building, 84 x 150 feet, have been awarded by the Gerlinger Electric Steel Foundry Co., West Allis, Milwaukee, Wis.

Notice of an increase in capital from $25,000 to $125,000 has been filed by the Kendall Foundry Co., 100 Arthur street, Buffalo, manufacturer of brass and other castings.

The Macungie Brass & Mfg. Co., Macungie, Pa., recently was reorganized under the name of the East Penn Foundry Co. Plans for the erection of plant additions are now being considered.

W. M. McIntyre, former sales manager for the Sharon Steel Co., Sharon, Pa., is reported planning the erection of a large foundry at Youngstown, O., opposite the plant of the Republic Iron & Steel Co.

The Mt. Clemens Foundry Co., Mt. Clemens, Mich., is being incorporated and is expected to manufacture automobile and tractor castings. The company will be capitalized at $500,000.

The W. H. Jahns Auto Machine Works, 920 West Pico street, Los Angeles, is in the market for molding machines, sand-blast equipment, tumbling barrels, core ovens and other foundry equipment.

A recent incorporation is that of the Norman Foundry Co., which was incorporated in New York with $15,000 capital, by J. and H. Miller and B. Zwerin, 856 Griggs avenue, Brooklyn, N. Y.

The Astoria Marine Iron Works, Astoria, Oreg., has purchased four miles of waterfront, and plans to erect a plant which will include a foundry, machine shop and steel fabricating plant.

The firm name of the Lister Sash Weight Co. of Missouri, St. Louis, has been changed to the Chemical Foundry Co. The plant is located on Dock street and the C. B. and Q. tracks.

The Franklin Service & Sales Co., Portland, Me., has been incorporated with $50,000 capital, to operate a foundry and machine shop, by Percy F. Frost, Clair R. Marston, Waterville, Me., and Sidney F. Thaxter.

The National Machine & Electric Co., East Russell street, High Point, N. C., has been incorporated to operate a foundry, machine shop, etc., with $125,000 capital. J. C. Smith, Herman Wood and Thomas G. Shelton are directors of the company.

The Denver Rock Drill Co., Denver, Colo., is erect-

ing a foundry, 60 x 140 feet. The equipment to be purchased includes core ovens, traveling cranes, molding machines, sand grinding machines, etc. The plant will be equipped with a 1-ton, 3-phase electric furnace.

The Framingham Foundries, Inc., Framingham, Mass., has been incorporated to succeed the business of the same name, with $500,000 capital. The incorporators are W. Emerson Barrett, Allan L. Priddy, Brookline, Mass., and E. G. Davis.

A foundry will be established at Columbia City, Ind., according to a current report. A site has been selected and a committee of the Columbia City Commercial club has the matter in hand. F. L. Meyers is a member of the committee.

The Kelsey Wheel Co., John Kelsey, president and L. C. Brooks, secretary, 1230 Military avenue, Detroit, is reported contemplating the erection of a foundry of brick and steel construction, on McGraw avenue.

A. Malza Products Corp. has been incorporated at Dover, Del., with $100,000 capital, to carry on a general foundry and machinery business. The incorporators are Samuel C. Wood, Arthur W. Brody, Chicago, and L. B. Phillips, Dover.

The core department of the National Radiator Co., Johnstown, Pa., recently was damaged by fire. A new structure is expected to be ready for occupancy shortly. Contracts for equipment have been let, according to R. D. Felton, purchasing agent.

The Portage Steel Foundry Co., Canton, O., recently was incorporated with $400,000 capital, by J. C. Atkinson and P. W. Schwartz, formerly of the Canton Steel Foundry Co. A modern steel foundry will be erected.

The Mueller Metals Co., Port Huron, Mich., has returned to normal production and is now working on orders for brass rods and brass and copper tubing, brass forgings, die castings, etc. The company is installing new equipment for the manufacture of crank-shafts and automobile parts.

The Schwarz & Schwarz Co., Cleveland, has been incorporated with $20,000 capital to operate a foundry and manufacture castings of all kinds. J. M. Schwarz, Joseph Hirshstein and others are the incorporators. Correspondence is being handled through Attorney Benjamin Schwartz, 114 Engineers building, Cleveland.

The Pennsylvania Iron & Steel Products Co., Ellwood City, Pa., is equipping two plants for the manufacture of gray iron, brass and aluminum castings. One plant already has been equipped and machinery for the other is arriving daily. The officers of the company follow: John A. Stewart, president; H. K. MacGeary, vice president; A. H. Simpson, secretary; John J. Book, treasurer and George C. Stone, general manager.

The Hoffman Bronze & Aluminum Casting Co., Cleveland, has completed the erection of a brick and concrete addition to its foundry building which provides 8000 square feet of additional floor space. This permits of the removal of the furnaces from the molding room, doubles the capacity of the core room and provides also a well lighted and convenient machine shop for finishing castings. The special machines for the production of close limit bushings for installation in the machine shop of this company now are being designed by the Kelly-Reamer Co., Cleveland. The capacity of the plant is now 10,000 pounds of nonferrous metal castings daily. Six additional molding machines also have recently been installed.

The Colonial Foundry Co., Louisville, O., has purchased the plant, including the foundry of the Bonnot Co., Canton, O. The company is capitalized at $65,000 and officers have been elected as follows: President, Clarence M. Converse, who formerly was affiliated with the Novelty Iron Co., Canton, and the Gilliam Mfg. Co. of the same place, in the capacity of vice president and sales manager. T. A. Jackson who was elected treasurer, was formerly superintendent of the plant of the Columbiana Pump Co., Columbiana, O., and superintendent of the foundry of the Gilliam Mfg. Co., Canton. Harry Connor, who was elected secretary, is superintendent of the Penn Mold & Foundry Co., Dover, O. The board of directors consists of C. M. Converse, T. A. Jackson, H. Connor, John T. Welter and Russell J. Burke.

The Manganese Steel Casting Co., Norfolk, Va., will erect an extensive electric steel casting foundry on a site of 10 acres. The building will include a foundry, 95 x 280 feet; pattern, grinding and machine shops, each 60 feet square; power house, 60 feet square; pattern storage, 30 x 60 feet; storage sheds, 30 x 220 feet; office, 30 x 60 feet and a garage, 20 x 40 feet. A wharf also is to be constructed, 50 x 450 feet, and the railroad sidings that will serve the plant will be 3000 feet in extent. A specialty will be made of cast steel car wheel tires, but in addition a general line of electric steel castings will be produced. All of the buildings will be of steel and concrete construction. The General Contract Co., Norfolk, Va., has been awarded the contract for the erection of the entire plant, including the equipment and this company also is doing the engineering work on a cost plus basis. Construction will begin about the middle of April.

NEW TRADE PUBLICATIONS

BELT FASTENERS.—A 4-page illustrated bulletin recently was issued by the Crescent Belt Fastener Co., New York, in which patented steel belt fasteners or plates are described. These plates are placed over the ends of the belt and fastened with self-piercing rivets. The bulletin gives directions as to the use of the metal plates and illustrations show their use with leather, balata and stitched canvas belts.

SHOVELS.—The Wyoming Shovel Works, Wyoming, Pa., has issued its fifth catalog describing its product. It illustrates some 30 varieties of shovels for different classes of work and outlines points in design which have an influence in the economy of handling materials. Special features of construction are analyzed and instructions are given for the preparation of specifications for types of shovels which are not listed in the catalog, or may be designed for a particular purpose.

BEARINGS.—The American Roller Bearing Co., Pittsburgh, has issued an 8-page booklet describing and illustrating roller bearings for use under conditions of medium loads at medium speeds. The castings and sleeves of these bearings, according to the booklet, are formed from cold-drawn steel, and after being machined are heat-treated and ground. The bearing cage consists of end rings joined by means of stay rods which also are formed from cold-drawn steel. Lists of prices and specifications are given.

ELECTRIC DRILLS.—The Independent Pneumatic Tool Co., Chicago, has issued a circular describing a variety of small electric drills. These are equipped with light motors which may be had either for direct or alternating current and for a range of voltages as desired. An aluminum crankcase is provided to decrease the weight and increase the convenience of handling and operating these drills.

LIGHTING FIXTURES.—A booklet devoted to industrial lighting fixtures has been issued by J. Livingstone & Co., Inc., New York. The subject of correct illumination is explained and it is pointed out that a correctly designed system of illumination will greatly aid in promoting production. Several types of reflectors are described and numerous illustrations are included which show lighting fixtures for various purposes.

WATER FILTERS.—The Griscom Russell Co., New York, has issued a bulletin describing a feed water filter and grease extractor for use in purifying feed water for steam boiler use. The device embodies a series of interchangeable envelopes of cloth mounted on wire-mesh rectangular frames, enclosed in a cast iron or steel shell. The area of filtering surface supplied is variable with the area of water passage desired. In each case the filter area is 500 times that of the inlet pipe.

SHIP CASTINGS.—A catalog devoted to gray iron ship castings has been issued by the Central Foundry Co., New York. Mooring fixtures and general castings are described and illustrated. These include air extractors, bitts, bollards, chocks, cleats, davit steps, fairleaders, mooring ports, mooring rings, chain pipes, hawse pipes, bilge and ballast flanged pipes, pipe flanges, hawser reels, coal scuttles, deck scuttles, sheaves and housings for limberchains and windlasses. It is pointed out that the constant changes being made in design necessitate many forms of ship castings due to lack of standardization.

ELECTRIC ARC FURNACES.—The Pittsburgh Furnace Co., Pittsburgh, has prepared a 16-page pamphlet which describes the use of electric furnaces in the steel casting industry. The refining action of the electric unit is compared in the abstract with the other steel melting mediums, and suggestions are offered for the economical operation of the former. An ideal layout for a foundry employing electric furnace melting is presented. A portion of the publication is devoted to the specific description of the furnace manufactured by this company.

PISTON VALVE STEAM ENGINE. — A 12-page bulletin illustrating and describing its high-speed piston valve steam engine, has been issued by the Ingersoll-Rand Co., New York. This engine is of the horizontal type and the steam valve permits of the use of the highest steam pressures and superheated steam. The bulletin contains cross-section illustrations, showing the machine in detail. In addition, the Ingersoll-Rand Co. has issued bulletins describing the Leyner oil furnace, tie tamping outfits and equipment for sugar factory and refinery service.

ELECTRICAL SUPPLIES.—The Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has issued a complete catalog of all the electrical supplies which it produces. Over 1250 pages are required to list the various articles. A complete cross index, an index to style numbers and a table of approximate cost multipliers from which to obtain a close estimate of the cost of each article listed, serve to make readily accessible the information contained. Although primarily a catalog, the volume contains much practical information for the engineer, particularly that portion which is devoted to suggestions for the use of apparatus described.

OXYACETYLENE WELDING.—A short course in the practice of oxyacetylene welding has been prepared by Alfred A. Kinsey, professor of shop practice at the Stevens institute of technology. This has been arranged in the form of suggestions for a number of lectures, combined with notes on the operation of the apparatus. These notes and suggestions are published in a most attractive form by the Air Reduction Sales Co., New York. It is recognized that the course will not make practical welders in 12 lectures and corresponding laboratory periods. The idea rather is similar to that which is the basis of all college shop practice—to furnish the students a first-hand acquaintance with an important branch of engineering experience. Complete apparatus is specified for the shop work in connection with the course. A color plate teaches the student to judge the correct flame for cutting and welding. The variation in flame color due to an oversupply of oxygen or acetylene is made plain. Drawings of welding, cutting, and combination welding and cutting torches make plain the details of the tools, and the mixer and pressure regulator device is visualized by a phantom photograph.